A portrait of gender in two 19th and 20th century Portuguese populations : a palaeopathological perspective

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A Portrait of Gender in Two 19^{th} and 20^{th} Century Portuguese Populations: A Palaeopathological Perspective.

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A Portrait of Gender in Two 19th and 20th Century Portuguese Populations: A Palaeopathological Perspective

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Abstract

The aim of this research was to attempt a portrait of gender in two Portuguese populations of the 19th and early to mid 20th centuries by analysing several markers of occupational stress (MOS). The 603 individuals used in this research were selected from the Coimbra Identified Skeletal Collection (CISC) and from the Lisbon Luis Lopes Skeletal Collection of the Museu Bocage (LLSC). The MOS used included degenerative bony changes observed in the articular surfaces of the synovial joints. The changes included marginal lipping (osteophytes), porosity, osteophytes on the articular surface and eburnation. Degenerative bony changes in the entheses were also analyzed; these were referred to as muscle stress markers (MSM). Further to these, data on the postcranial indices were also included, as well as other occupational markers such as trauma to the long bones, non-specific periostitis of the tibiae and fibulae, and vertebral lesions known as Schmorl's nodes and spondylolysis were considered.

The assumption underlying this research was that the MOS would reflect the sexual division of labour, present in society, and that this would mirror gender constructs. The differential markers of occupational stress would be related to male/female task performance differentiation. To test this assumption several hypotheses were formulated and tested.

The results showed that the occupational category used in the research did not allow for a portrait of gender through MOS. The age at death of the individuals revealed to be a major confounding variable throughout the analysis of the degenerative bone changes observed in the joints and entheses. Several occupational related statistically significant values were achieved; however, these contradicted the premise that a more strenuous activity would be synonymous with higher values of lesions. Furthermore, the majority of females were grouped into a single occupational category, *housewives*. This category proved to be an unsurmountable bias whilst analysing MOS and occupational groups. Additionally, the review of the methodologies, which include the recording methods, proved that the MOS were not fully adequate for the assessment of activity/occupational-related bony changes.

The major conclusions drawn from this research were that there is an urgent need for re-evaluation the methodologies employed in the assessment of MOS. The inherent limitations in the current MOS methodologies render the evaluation of activity–related bony changes impossible. Ultimately, gender as a *social construction* is not a *biologically identifiable trait* in skeletal material. Many variables other than MOS need to be explored in the analysis of the social dimension of past human societies within the field of bioarchaeology.

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Abbreviations

BFA	Bone functional adaptation
CISC	Coimbra Identified Skeletal Collection
C-SG	Cross-section geometry
DBC	Degenerative bony changes (joints)
DI	Diaphyseal index
DJD	Degenerative joint disease
DISH	Diffuse idiopathic skeletal hyperostosis
EDM	External diaphyseal measurements
Fe	Fibrous entheses
FCe	Fibrocartilaginous entheses
HACML	Historical Archives of the Câmara Municipal of Lisbon
LLSC	Luis Lopes Skeletal Collection
MSD	Musculoskeletal disorder
MSM	Muscular stress markers
MOS	Markers of occupational stress
OA	Osteoarthritis
O.MOS	Other markers of occupational stress (trauma, periostitis, spondylolysis and schmorl's nodes)
RI	Robusticity Index
RM	Robusticity marker
PI	Platymeric (femur) and platycnemic (tibia) indices
SL	Stress lesion
WHO	World Health Organization

Chapter 1: Introduction

In a bioarchaeological context the importance of the study of gender was highlighted by a series of scholars in the 1990s. It was argued that the study of human skeletal data needed to take into account the social dimensions of human society. The full understanding of human behaviour could only be achieved if human remains were analyzed and understood within their biological, social, cultural, economical and ecological milieux. Humans not only exist as biological beings, but also as social agents that can shape, and be shaped by the cultural, social and physical environment around them. It was also proposed that the distinction between sex and gender, in paleopathological analysis, was of major importance, as men and women experience life differently. This differentiation is strongly based on biology, but it also portrays men and women's socio-cultural dimension. Biology and culture have intrinsic meanings which are intertwined and can ultimately influence each other (Grauer and Stuart-Macadam, 1998; Walker and Cook, 1998). It was this line of investigation that inspired the research developed in this doctoral thesis.

This study aims to explore the potential of studying gender differences from a palaeopathological perspective using skeletal remains of known documented individuals from late 19th and early 20th century Portugal. The research seeks to assess the validity of using Markers of Occupational Stress (MOS), as indicators of levels of physical activity, to infer gender related activity changes. Paleopathological changes, within the framework of bioarchaeological research, will be used to look at the connection between MOS and gender. The MOS analysed include or included pathological and non-pathological conditions. Among the first two major conditions considered are degenerative bony changes of the joints, namely marginal lipping (osteophytes), porosity, osteophytes on the articular surface and eburnation, also used to assess osteoarthritis (OA), and muscle stress markers, more commonly known as enthesopathies. In addition, the presence of other pathological conditions such as trauma to the long bones, non-specific periostitis of the tibiae and fibulae, and vertebral lesions known as Schmorl's nodes and spondylolysis, are assessed. Regarding non-pathological conditions this research also analyses asymmetry of postcranial indices which reflect limb size and shape.

Two major objectives in the analysis of MOS are pursued. On the one hand individual degenerative bony changes are analysed to discuss whether males exhibit more activity-related osseous changes than females, and whether there are osseous changes, or patterns of osseous changes, more particular to men or women, or related to a specific occupation. Additionally, the impact of age on the existence of any particular osseous change is considered. This project also looks at occupational groups' differentiation on the basis of the biological changes. Firstly, it will be consider whether activity related osseous changes surveyed reflect sexual division of labour in the skeletal samples studied, and secondly whether the social construct of gender can be inferred and/or studied through the use of human skeletal remains.

The study achieves these objectives using two skeletal collections coming from two major Portuguese cities, Coimbra and Lisbon dated from the 19th and 20th centuries. The skeletal collections are the Coimbra Identified Skeletal Collection (CISC) and the Luis Lopes Skeletal Collection of the Museu Bocage (LLSC). The known information about their historical, social, cultural and geographical context, make these collections ideal for generating data which can be applied to bioarchaeological research on human behaviour. Importantly, this information includes biographical records of the people represented by their skeletons, comprising in most cases data on sex, age at death, birthplace, cause of death and occupation. Contrary to archaeologically derived human remains, the use of identified skeletal collections provides a wider range of data that can be used to develop and test theoretical and experimental models which cannot be performed in archaeologically derived human remains, due to the incompleteness of the data. Furthermore, because the social, cultural and economic context of these collections is known, they are unique and ideal for testing hypotheses related to social categories, such as gender. The known social context of these identified skeletal collections was thus the major motive behind the development of the present study. The objective was to use sex-related health differences (between male and female) to explore gender-related health differences. Consequently there are two major areas of research being dealt with throughout the present work: firstly biological, which focused on the analysis of skeletal changes associated sex and with activity, or occupation; and secondly a social and cultural dimension, in which gender is addressed, and skeletal changes are interpreted within the scope of social performance.

To explore whether the data gathered could be used in the assessment of gender-related differences, several hypotheses were tested. The hypotheses focused on the biological and social dimensions of the data collected. With regard to MOS the hypotheses tested addressed whether males exhibit more activity related osseous changes than females; if particular osseous changes, or pattern of osseous changes, were more prevalent in men or women; and, finally, if age influences the existence of any the osseous change analysed. The hypotheses developed in order to analyse whether there was any relationship between gender and MOS surveyed focused on the analysis of occupational groups' related changes. The hypotheses tested were: do MOS recorded reflect the sexual division of labour known to exist in these samples; can patterns of MOS be associated with specific occupational groups; and can the social construct of gender be analyzed / studied through the use of MOS?

During the research undertaken, the initial aim of exploring gender differences was tested and considered. However, through the data collection and analysis it became clear that some of the obstacles encountered were not related to the aim of the research, or with the argument under evaluation, but with the underlying bioarchaeological methods applied to the argument. Consequently, one of the major outcomes of this thesis is a critique of the methods usually employed by bioarchaeologists to infer degenerative bony changes, specifically osteoarthritis. Another result is to review the assessment of social categories in bioarchaeology, particularly if that assessment is conducted using a paleopathological approach.

The thesis is organized into nine chapters, including this brief introduction. Chapter 2 focuses on the discussion of the definitions of gender and sex, and on the importance of feminist critique in bioarchaeological, and archaeological contexts. An overview of the role played by feminist critiques will be presented. Another major issue addressed will be the importance of distinguishing between sex and gender, and how this distinction has been achieved in bioarchaeological contexts. The acknowledgment of sexual division of labour as a major foundation of gender distinction, and of human performance, as relevant in bioarchaeology analysis is also addressed. The aim of this chapter is to contextualise the importance of gender studies in archaeological research, and centre its significance in bioarchaeological studies.

Chapter 3 is an overview of the use of *Markers of Occupational Stress* (MOS) in bioarchaeological contexts, and the contextualization of gender in paleopathological analysis. A synopsis on the use of MOS is provided, with brief definitions and a discussion of the methods used in their assessment; their importance and relevance for today's bioarchaeological research is also argued. Whenever necessary, a critical review of the most updated, as well as classical, literature will be presented. Following the MOS overview, Chapter 4 presents the bioarchaeological parameters recorded, and the statistical methods used. This chapter has been placed before the introduction of the skeletal samples used as it seems more helpful to have the methods described following the MOS summation (Chapter 3), in order to explain and easily comprehend some of the changes introduced to the original methods proposed. Although this structure contrasts to the more traditional organization of this type of work, the overall content is present.

Chapter 5 is entirely dedicated to the skeletal samples (Material). This was of enormous importance for the research as it supported the understanding of the social and cultural dimension of the data analysed. Of particular importance was the discussion of the role of women and men in the Portuguese society, and of their "duties" and "obligations" within the framework of sexual division of labour. The Chapter is divided into three major sections; each contributes to the overall knowledge and contextualization of the skeletal material within its historical, social, cultural and economic context. In each section, the sample selected is presented, and its description is discussed within its appropriate context. Apart from the analysis of the skeletal remains, a brief history of the skeletal collections is also be provided as it contributes to the overall understanding of the skeletal material analysed.

Chapter 6 addresses the first set of results. These focus on the analysis of individual degenerative changes observed in the joints and entheses. The analysis of these results leads to the transformation of the original data into new variables, analysed in Chapter 7. The major importance of Chapter 6 is the overall discussion of the methods of recording, and analysis of degenerative bony changes observed in the joints and entheses. It briefly addresses some of the major problems of in bioarchaeological studies of MOS; specifically the overall lack of systematized recording and use of diagnostic criteria. It ultimately suggests that bioarchaeology needs to develop alternative methods of recording and analysing of degenerative bony changes, and all researchers need to use one system. Present and future research can no longer be based on classic methods.

Chapter 7 addresses the second set of results. These results derived from the analysis of the "transformed" variables described in Chapter 6. The results of the analysis of the remaining skeletal markers (postcranial indices, trauma, periostitis, and vertebral lesions) are also presented. This chapter focuses on occupationally related differences between the bony changes analysed; consequently, the discussion addresses the biological dimension of occupational group differences. During the discussion of these results, additional tests were performed on the data, so that questions that arose during the discussion could be further tested.

Chapter 8 brings the biological data into the social and cultural dimension of the thesis. It explores the possibility of inferring social categories using biological data derived from the skeletal remains. It discusses the results within the historical, social and cultural context of the sample introduced in Chapter 5, and addresses relevant aspects of discussions of the individual degenerative bone changes, as well as issues related to the occupational group analyses. It ultimately discusses the overall development of the research, and culminates with final remarks on bioarchaeological research on gender and its potential relationship with degenerative bony changes.

This study was developed as an attempt to integrate biological, social and cultural data. One of the major conclusions was that this is not as simple as some authors have proposed in the past. The complexities of recording, analysing and interpreting MOS, and individual pathological conditions that may be related to occupation, along with studying gender in a bioarchaeological context have not been adequately assessed by previous literature. The difficulties encountered in this research ultimately results in the recommendation of the urgent need in bioarchaeology to develop new methods of paleopathological assessment in studying occupation and its relationship to socio-cultural context. My immediate future research will be focussed on following up these conclusions.

Chapter 2: Gender, Feminism, Archaeology and Bioarchaeology

This chapter will focus on the discussion of gender and sex. Firstly, the importance of feminist critique in bioarchaeological, and archaeological context will be briefly discussed. Secondly, sex and gender will be defined within a bioarchaeological context. The discussion addresses the importance of distinguishing between sex and gender, and how this distinction is achieved in a bioarchaeological context. The final section addresses the interpretation of human behaviour through the sexual division of labour, and how this social dimension of human performance can be used in gender assessment through paleopathological analysis. It is important to discuss the impact of feminist critique, as it was one of the pivotal contributions to the recognition of the importance of gender in interpreting the archaeological and bioarchaeological record. The plethora of published articles in which gender has been a research variable attest its importance (Armelagos, 1998; Hollimon, 2000). The acknowledgment of gender significance was born within the feminism critique, and its implications need to be addressed within feminism agency.

2.1 The importance of feminist critique in gender studies

The following sections will comment on the impact of feminist criticism on social knowledge, and on the awareness of the importance of social science theories within archaeological and bioarchaeological contexts. The discussions on gender issues are a mere introduction to the vivid discourse between social sciences theories and archaeology, as well as bioarchaeology specifically addressed in this research

(Claassen, 1992; Claassen and Joyce, 1997; Geller and Stockett, 2006; Gero and Conkey, 1991; Gilchrist, 1999; Gowland and Knüsel, 2006b; Mascia-Lees and Black, 2000; Nelson, 2006; Sofaer, 2006a; Sorensen, 2000). For instance, the increasing attention paid to the phenomena of multiplicity between genders, as a particular aspect of human behaviour, is also a fairly recent development of research within the sphere of human bioarchaeology (Geller, 2005;Hollimon, 2000, 2001, 2006; Stockett, 2005). Researchers may vary in perspective, as well as in theoretical orientations, but they all perceive gender as socially multifaceted and fluid (Gilchrist, 1999; Miller, 1993; Sorensen, 2000; Wright, 1996).

These new theoretical approaches to archaeological data brought a new appreciation to the diversity of gender in past human societies. An example of the incorporation of gender diversity within bioarchaeological research is Hollimon's (2001) reappraisal of the osteological indicators of conflict-related injuries among Arikara-affiliated groups. The data was re-analysed in the context of "women warrior" roles, and a new gender perspective was introduced in the interpretation of the osteological human remains (Hollimon, 2001). What she had previously considered (Hollimon, 2000) "that Arikari women cowered in their doorways or cornfields during raids upon their villages and gardens" (Hollimon, 2001: 179) was reinterpreted in the light of her new approach. One of the conclusions was that, contrary to what Hollimon had presented, not all women were passive victims. Some female skeletons displayed traumatic injuries compatible with the alternative gender role of "women warrior". These women participated in organized warfare, as suggested by ethnographic and ethnohistoric information, and were not mere victims. This new vision of women's behaviour is a fine example of the importance of analysing the data within its original social and cultural context. It also illustrates that inferences drawn from bioarchaeological analysis may be biased by the researchers approach to the data. Most importantly it illustrates the importance of considering social categories, such as gender, as research variables.

1.1.1 Knowledge production and feminist critique

The feminist critique was a major contributor to the deconstruction of the assumptions made about gender and sex in societies (Moore, 1998). Although the critique grew out of the concern over sex discrimination and social inequality, it wisely evolved into a theoretical framework of knowledge production. Feminist critique developed its specific "intellectual tools" that assist the understanding of human behaviour in the past, present and future (Geller and Stockett, 2006; Lamphere, 2006).

The primary objective of the feminist criticism was social criticism. The criticism was centred on women's social inequality. Women were "invisible", "mute" and exponentially marginalized in social life. Men had established themselves as the bastion of human knowledge, and were socially empowered (Gilchrist, 1999; Sorensen, 2000). In this sense feminist critique emphasised women's needs to express and articulate their perspectives, and experiences, in the sphere of human relations as rightful members of human society (Gilchrist, 1999). Feminism awakened the political conviction for change, and challenged existing power relationships between men and women (Gilchrist, 1999; Morgen, 1989; Sorensen, 2000).

The feminist critical approach to the *establishment* is characterized by three major discursive *waves*, each one representing a shift in the feminist concerns. The first wave refers to the suffrage movement, between the 1880s and 1920s, through which women achieved public emancipation and rights in the realm of politics, education and employment (Gilchrist, 1999). The second wave, in the late 1960s, focused more on issues of women's equality in relation to sexuality, reproduction, and fulfilment in private and public spheres. A search for equality was central to most of the discourses. Feminist scholars examined the way in which inequalities and male bias had impacted on their own discipline. Severe critiques of androcentrism in the study of history, anthropology, primatology and other social and natural sciences were one of the main issues addressed (Conkey and Spector, 1984; Derevenski, 1997; Di Leonardo, 1991b, 1991a; Gilchrist, 1999; Morgen, 1989; Sorensen, 2000; Spector, 1991). The third wave, also referred to as postmodernist feminism, emerged over the last decade and centred more on the cultural and symbolic meanings of gender, with an emphasis on difference and diversity (Gilchrist, 1999). Postmodernist feminism rejects universal laws and/or notions of human experience, accentuating cultural relativism and personal experience (Butler, 1990, 1993; Gilchrist, 1999; Spector, 1991). Feminists moved from a concern with equality or inequality, almost exclusively between men and women, to promote the concept of *difference*. Theories of polarised male-female sexuality and social discrimination were reviewed. Gender differences were no longer solely the result of essential biological interpretations of being a male or female. Gender differences were also acknowledged as having emerged from experiencing culture (Butler, 1993; Gilchrist, 1999; Moore, 1994). In the framework of postmodernist feminism gender, sex and sexuality are discussed and given new meanings. Inclusively, sex acquires a social and cultural characteristic. It is perceived as a cultural construct in the sense that the knowledge of men and women's biological nature depends on the evolution of scientific knowledge, which is *per se* a product of its time. The perception of an individual's sexual nature is intimately related with what is known about sex, and what is known about one's sexual nature has changed over time (Laqueur, 1990). Currently, and within the framework of postmodernist feminism, the binary references to biological sex are being redefined by queer theories[1] (Dowson, 2000; Voss, 2000), individual performances are taken as an important process in assimilating cultural categories, such as gender and sexuality (Butler, 1990, 1993). Furthermore, because men are no longer the "enemy", there is also an emerging masculine perspective (Breitenberg, 1996; Fisher, 2001). The concept of masculinity is re-examined as a multi-dimensional feature that is selectively adopted by men and sometimes women (Gilchrist, 1999). In this context the term masculinity is distinct from the exclusive and intransigent gender-biased androcentric position fought by early feminists (Knapp, 1998). More importantly, the masculinity research has insisted upon the existence of divergent and multiple masculinities, rather than a binary opposition that once characterised most gender-based research (Knapp, 1998). The emphasis placed on terms such as "difference", "multiple", "coexistence", and even "individuality" has prevented the replacement of the traditionalist androcentric view of society and

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[1] Queer theory is theoretical framework of social speculation, which grew out of feminist studies and feminist theory (Sullivan, 2003).

culture, by a modern "gynecentric" one in which women would dominate (Conkey and Gero, 1997; Knapp, 1998; Lesick, 1997; Whitley, 1998). In the end, although feminism developed from androcentric critiques, and the initial research focused on women, the most recent stage of knowledge production is that of integrative theories concerning sex and gender, including material conditions and socio-cultural dimensions. It provides a sophisticated understanding of gender which could be applied to archaeology, as well as other disciplines (Wylie, 1991)

1.1.2 Engendering archaeology: from critique to *praxis*

Engendering archaeology was one of the causes, and effects of the turmoil of knowledge re-appreciation produced by feminist criticism. As in many fields of human studies the introduction of feminism's perspectives lead to the re-thinking, and re-analyses of existing archaeological assumptions (Boyd, 1997; Claassen, 1992; Di Leonardo, 1991a; Gero and Conkey, 1991; Gilchrist, 1999; Hurcombe, 1995; Lesick, 1997; Sorensen, 2000; Spencer-Wood, 2001). The article published by Conkey and Spector, *Archaeology and the Study of Gender,* in 1984, stands as one of the first papers to address, and critique, the male domination of archaeology. Their paper is understood as a landmark in post-modern feminism interpretation of archaeology, urging for the creation of a *gendered archaeology* replacing the existent *andocentric archaeology* (Conkey and Spector, 1984; Gilchrist, 1991, 1999; Knapp, 1998). In fact, androcentrism, mythologism and presentism were all "*isms*" criticised by feminist theories. The first, already mentioned, was a direct consequence of the male bias. The majority of archaeologists were men, discoursing about men, from a western, male dominated perspective. Further to the male dominance in the discipline, most of the time the information collected was based on male informants only. Consequently, and as understood by feminist criticism, the archaeology being practiced was an ostensible production of knowledge, referred to as "gender mythology." It was denominated as such because the real contributions and experiences of both men and women of the past were no more than a mere shadow filtered by the personal, and ethnocentric view of the researcher concerned with the task at hand (Conkey and Spector, 1984; Gilchrist, 1991, 1999; Knapp, 1998).

The critical posture of second wave feminism was a powerful tool to explore, and denounce, this notion of "gender mythology". The second wave feminism also criticised the meaning of masculinity and femininity as culturally specific beliefs, the overall assessment of male-female capacities and their role on society, and the notion of "power" relationships (Conkey and Spector, 1984). The problem was not necessarily that males dominated, but that this male supremacy was authenticated throughout cultures. Archaeology was perpetuating a "gender mythology" by employing gender stereotypes based on contemporary perceptions. Archaeologists were applying a long-standing cultural continuity of perceptions of gender roles, and embedding prehistory with recent notions of gender (Conkey and Spector, 1984; Conkey and Williams, 1991; Gilchrist, 1999). This cultural continuity, from prehistory to actuality, reinforced the idea of "presentism", in the sense that the past was reconstructed applying socio-cultural characteristics that were observed in present societies (Conkey and Spector, 1984). These were, once more, reinforcing andocentric and ethnocentric perspectives in knowledge production (Arnold and Wicker, 2001; Conkey and Spector, 1984; Hurcombe, 1995; Nelson, 1997; Sussman, 1999). In this context archaeology was neither objective nor inclusive, hence the strong denomination of "myth" (Conkey and Spector, 1984). Apart form the male bias, the informant point of view was itself a source of bias. On one hand there was the imposition of ethnocentric assumptions about the nature, role, and social significance of women and men in society. On the other hand, more credibility was given to the information provided by male informants. They were perceived as more reliable than women simply because they were men. It was thus the male perspective that was taken as representative of the culture under study (Conkey and Spector, 1984). Men were portrayed in reference to western views, and women were always portrayed in reference to their male counterparts. The general cultural tendency was to define men in terms of their status and role categories, such as warrior, hunter or elder; while women were defined almost entirely in relation to men (Gilchrist, 1999; Ortner and Whitehead, 1981). Women were always marginalized and rarely accepted in the mainstream of archaeology, as both subjects of study and also as agents of knowledge production (Boyd, 1997).

After exploring the male bias inherent in archaeological discourses, the development of methodologies used to study gender archaeology seemed an essential prerequisite for the systematic revision, and replacement, of androcentric treatments of the past (Spector, 1991). The concerns of gender archaeology matured from the feminist critique of androcentrism, to a more holistic study of the meaning and experience of sexual differences and gender identity in the past (Moore and Scott, 1997; Scott, 1997). Assertions about gender differences were no longer encapsulated in the binary assumption of sexuality, and gender did not conform to any fixed identity, time, or space (Bly, 1993; Gilchrist, 1999). A new dimension of gender was brought in, one connected with individual agency, performance, identity and causation (Bly, 1993; Butler, 1990, 1993; Knapp, 1998; Lesick, 1997). Sex perceived as a stable biological category, antonymous to gender which was socially created and representative of fluidity, was also in the core of feminism critique. The major consequence of this new approach to sex, was that the traditional perspective of sex and gender was challenged (Coontz and Henderson, 1986; Gilchrist, 1999; Keller, 1997; Knapp, 1998; Laqueur, 1990; Mascia-Lees and Black, 2000). Queer theories were the arena for questioning the predetermined categories of sex, gender and sexuality (Dowson, 2000; Voss, 2000). Individuals live in a gendered body and create the appearance of sex through performance (Butler, 1990, 1993; Gilchrist, 1999; Meskell, 2000). Hence, the physical characteristics could no longer account for the differences in gender roles encountered in societies, and those same differences could no longer account for biological sex either (Coontz and Henderson, 1986; Leibowitz, 1986; Voss, 2000). Both sex and gender were socially constructed categories, and sexual inequalities would be socially produced rather than biologically determined (Gilchrist, 1999). Ultimately, gender archaeology was no longer content with the binary categories of sex, nor with the sexual division of labour theories. Gender differences were found through private experiences and sensations of being a man, a woman or "other" through the life-course. This change, in the perception of gender in archaeology, also brought novelties to the analysis of human skeletal remains. Bioarchaeological analyses became aware of the diversity of gender in past-archaeological context, and that gender and biological "skeletal" sex may not necessarily be synonyms (Geller, 2005; Hollimon, 2001; Stockett, 2005).

In summary, the discussion about gender and sex has been one of the major social and cultural concepts addressed by feminist critique. It may have started with the objective of rendering women visible in the archaeological records, giving them a place, history and voice, but it has currently outgrown these aims. It has fully developed into a methodological approach to questions related with gender, sex and sexuality in many social sciences, including anthropology and archaeology, and consequently bioarchaeology (Arnold and Wicker, 1999; Arnold and Wicker, 2001; Casey *et al.*, 1998; Claassen, 1994; Claassen and Joyce, 1997; Conkey, 1993; Conkey and Spector, 1984; Coontz and Henderson, 1986; Cros and Smith, 1993; Di Leonardo, 1991a; Díaz-Andreu *et al.*, 2005; Jaggar, 1997; Nelson, 2006).

2.2 *Sex and Gender: from bioarchaeology to biocultural approach*

In the current research sex and gender will be used to identify two different concepts. Gender will be understood as culturally constructed, and defined as "the cultural interpretation of sexual differences that results in the categorization of individuals, artefacts, spaces and bodies" (Gilchrist, 1999: xv). As a culture construct, gender possesses multiple social dimensions distinguished as: gender roles[2], gender identity[3] and gender ideology[4] (Gilchrist, 1999). Sex, on the other hand, will be comprehended as "the specific genetic and hormonal make up of individuals and their subsequent development of secondary physical characteristics which place individuals in the category 'female' (XX chromosomes) or 'male' (XY chromosomes)" (Pollard and Hyatt, 1999: 2). In the particular case of human skeletons, sex focuses on the secondary physical characteristics attributed to male and female individuals. As such, the sex would supposedly be based on a universal binary biology, with an individual being either male or female. Gender, on the other hand would have its roots in culture and society, allowing for diversity and multiplicity beyond the sphere of binary biology (Gilchrist, 1999; Whitehouse, 1998).

The importance of the study of gender in bioarchaeology is intimately related with the social sphere in which an individual exists. The human being is both a social as well as a biological being, and gender and sex concepts reflect those categories. Consequently, they can both be used as analytical tools in the study of human behaviour. What should not happen, although unavoidable in many cases, is to use

[2] Gender roles may be understood as the differential participation of women and men in social, economic, political, and religious contexts within a specific cultural setting. It describes the activities and statuses that are associated with specific genders in particular societies (Conkey and Spector, 1984; Gilchrist, 1999).

[3] Gender identity refers to the private and individual experience of gender. It may not necessarily coincide with the gender category assigned to a person by society. The category is expressed outwardly through physical and material expressions (Conkey and Spector, 1984; Gilchrist, 1999).

[4] Gender ideology conveys the meaning of male, female, sex and reproduction in a given social and cultural context. The emphasis is on gender, sexuality and reproduction as symbols. This category includes the prescription and proscription for male and female, or persons of any other culturally defined gender category (Conkey and Spector, 1984; Gilchrist, 1999).

the word sex and gender as euphemistic synonyms. Gender has recurrently been used as a substitute of sex, as a more polite and politically correct reference (Gentile, 1993; Kim and Nafziger, 2000). However, the confusion brought by this interchangeability should be enough to discourage such a practice, as it brings much confusion in the interpretation and analysis of social behaviours (Gentile, 1993; Unger and Crawford, 1993; Walker and Cook, 1998; Worthman, 1995). Furthermore, the distinction between sex and gender should be preserved as it brings strength, and meaning, to the analysis of human behaviour. One needs to be reminded that human beings exist in the crossroads of biological and cultural behaviour, to disregard this or give authority to either biology or culture would be analytically incapacitating. "Without the distinction between gender and sex, studying gender roles in ancient societies [as well as present ones] becomes a virtual impossibility" (Walker and Cook, 1998: 256). Nevertheless, terminological confusion exists, and its controversy is far from ending, hence the importance of discussing sex and gender differences in bioarchaeology.

2.2.1 Sex and Gender: biological or socio-cultural *properties*?

When dealing with such volatile terms, sex and gender, each one strategically placed between the human limits of biology and culture, it is necessary to rely on definitions and use them consistently. Douglas Gentile (1993) made such an attempt, and used the causal relation between biology and culture to develop new criteria for the terms used. He identified five situations in which social scientists use the words sex and gender, all based on the underlying relationship between biology and culture. The terms included: sex, biologically sex-linked traits or differences, gender-linked traits or differences, sex and gender-linked traits or differences, and sex-correlated traits and differences (Gentile, 1993; Unger and Crawford, 1993; Worthman, 1995: 122). However, and despite efforts such as these to develop a standards terminology for the classification of sex and gender, confusion persists and, as worded by Rhoda Unger and Mary Crawford (1993: 123), "simply tightening up our linguistic labels will reduce the confusion in this area". This is particularly true since the strict definition of sex, as a biological trait, has been questioned by many researches who have started to interpret the divide of human beings according to their sex (either as male or female) as a cultural product (Keller, 1997; Laqueur, 1990). Recently, sex has acquired a cultural and historical dimension, weakening its notion of biological determination, abusively used in the naturalization of gender differences. Thomas Lacquer's (1990) dissertation about body, sex, sexuality and gender from ancient Greece to Freud, showed that sex has an historical dimension. What we would normally perceive as scientific knowledge, may be dependent on the progression of that knowledge through time. During the eighteenth and nineteenth centuries sex was not defined by today's medical standards (Harvey, 2002; Laqueur, 1990). In the eighteenth and nineteenth centuries a "one-sex model" prevailed, in which female sexual organs were an equivalent to the inverted male ones. This was perceived as "natural". This model was latter replaced by a "two-sex model", in which male and female were two separate sexes. Laqueur's perspective relies heavily, as do many of the studies dwelling on sex and gender differences, on second-wave feminist theories aimed at combating notions of women's "natural" inferiority (Altman and Nightenhelser, 1992). The perception of sex as being historically constructed contributed to the criticism of biological and natural determinism. Once free from the assumption that biology is fixed and gender constructed, the discussion embraced by social sciences has many avenues. As proven by the Queer Theories, there are numerous other ways in which sex and gender can be defined, constructed and discussed, all of them positively contributing to the understanding of human behaviour within the realm of sex and gender (Sullivan, 2003).

In summary, to say that sex is biological and gender cultural is not as clear cut as commonly perceived. Each definition needs to be interpreted within the context in which it is used. The ideal situation would be to find an hermetic definition of the concepts; however, that has proved an impossible task. One needs to embrace that fact that sex and gender are both to be given a cultural, social, geographical and historical dimension (Hodder, 1997; Moore, 1997; Ortner and Whitehead, 1981).

2.2.2 Are there really *Gendered* skeletons?

The importance of addressing gender and sex-related issues in social sciences, such as anthropology, archaeology and, ultimately in bioarchaeology, resides in the fact that skeletal remains are the core of much research being undertaken in human behaviour. What one observes in bioarchaeological contexts are the physical remains of individuals. The understanding, and reconstruction of those individuals' behaviour is inferred through their physical remains, which are ultimately employed as surrogates for gender behaviour.

In bioarchaeological context, human skeletal remains are most of the time stripped of (human) tissues, clothes, jewellery and other "paraphernalia" used *in vivo* to identify a person as male, female, or as a member of a particular stratum of society, region, or gender. The socio-cultural dimension of human skeletal material is believed to be tangible thought the analysis of the material culture associated with the burial. Scientists rely on these data to infer upon a skeleton´s cultural and social status (Criado, 1995; Groves, 2006; King, 2004; Pearson, 1999; Savage, 2000; Vanhaeren and d'Errico, 2005). Therefore, whilst one may argue that the determination of sex is a reasonable and achievable task using skeletal remains, the assessment of gender, or other social and cultural category may be impossible if based solely on the analysis human skeletons (King, 2004; Pearson, 1999).

Bioarchaeological research focused on the study of gender in past populations has used human skeletal remains as its mediator. This as been done based on the assumption that skeletons could render gender highly visible and tangible, particularly when used in conjunction with material culture associated with burials (Grauer and Stuart-Macadam, 1998; Larsen, 2006). Engendering a skeleton would therefore be possible, as long as skeletons are associated with a particular material culture context, of known social and cultural meaning (Lesick, 1997). In this scenario the use of human skeletal remains would be a mere addendum to the meaning displayed by material culture/grave goods. Such an approach would require a faultless understanding of the connection between the material culture in question, and the gender roles in that culture. Only then could the physical (material culture) be used to assess the abstract (gender) (Lesick, 1997). However, it should be stressed that material culture alone should never be employed as a method of sexual diagnosis in skeletal material. Sex assignment to skeletons must always be based on the osteological material. In the end, the best way to achieve a complete and reliable picture of gender is to base its interpretation on multi-data references.

Further to the importance of material culture in gender assignment, skeletons may also be used in gender assessment. Human skeletal remains and material culture can both contribute to the portrayal of human gendered behaviour. Both approaches are based on the fact that gender has a strong influence on a person's behaviour, and that a gender-specific behaviour would be either expressed trough the use of gender-specific material culture, or through behavioural patterns related with occupation and/or physical activities. In the former, emphasis is placed in the burial goods and funerary context. In the latter the skeletons are embodied with social and cultural significance, that is believed to be accessible though the analysis of skeletal markers of occupation. Both approaches to gender should neither be exclusive nor dominant. They should be considered complementary, since information drawn from both contextual research approaches can provide pertinent information (Robb *et al.*, 2001).

One must be extremely wary of presumptions made on the importance of grave goods above the skeletal remains themselves. Often, contradictory evidence may be presented, such as "discovering" a skeleton sexed as female associated with male artefacts. In such cases it is important to neither exclude, nor give emphasis to grave-goods above skeletal remains and *vice versa.* Alternative interpretations of the context in which this situation occurred should be explored. In such circumstances, it is important to consider the possibility of third-gender individuals (Geller, 2005; Hollimon, 2001; Stockett, 2005), in the appropriate geographical, chronological and ethnographical context: or that the grave-goods may not mirror life's social realities, but may represent the remains of a ritual processes related to the mourners rather than the dead (King, 2004; Pearson, 1999).

It is therefore appropriate to question the significance of the relationship between sexable skeletons, material and gender. The institutionalized notion that certain objects will belong to a particular sex (e.g. weapons to men; earrings to women), or that a particular sex would only be associated with certain types of objects, may hide the real relation between material culture and body (Crass, 2000; Goldstein, 2006; Gowland and Knüsel, 2006a; Sofaer, 2006a, 2006b). Furthermore, a strong association such as this, in which a skeleton is either male or female, with objects being allocated to either category, denies the possibility of exploring the multitude of gender roles known to exist in society, as well as in the sexed skeleton. Gender exists beyond the binary biological identity as proven by the existence of third-gender categories (Geller, 2005; Hollimon, 2001, 2006; Stockett, 2005). In some societies the cross-gender roles occupy a permanent ontological space between male and female through an institutionalized third-gender (Gilchrist, 1999). Such are the examples of the Indian *hijra*, the Byzantine eunuch and the Native American two-spirit (Gilchrist, 1999). All of them blur the boundaries between sex, gender and sexuality and they all break down the binary categories of male-female sex. Gender is in the body, but it cannot be reduced to mere biological differences. Gender is experienced as an identity that is personal and mutable rather than externally inscribed and fixed. The potential of multiple gender categories is explored through cross-cultural gender types which possess social, physical and archaeological characteristics (Fulton and Anderson, 1992; Geller, 2005; Gilchrist, 1999; Hollimon, 1992, 2001; Stockett, 2005). The archaeological record can be ambiguous and alternative interpretations are inevitable, but this recognition of difference and ambiguity encourages dialogue between data and theory, past and present, writer and reader, text and context (Geller, 2005; Knapp, 1998; Stockett, 2005). Moreover, sex itself is not *bi*, but *multi* due to the existence of intersex categories (Blackless *et al.*, 2000; Fausto-Sterling, 1993, 1999, 2000a, 2000b, 2005). The binary sex-system implanted in our society (western) is hardly adequate to encompass the full spectrum of human sex/sexuality, neither is the present bioarchaeological research.

According to Joanna Sofaer (2006) the methodology used to assess sex in human skeletal remains recognises, to a certain degree, the variation in morphological expression of the sexes in different skeletal samples. This is because the methods used foresee a continuum of morphological variability from an individual that is classified as male, to one classified as female. This "continuum" is specifically observable in the methods employed to assess sex based on cranial morphological traits. The traits rely on sexually dimorphic cranial morphological characteristics. A more robust, or pronounced nuchal crest, mastoid process, glabella or supraorbital margin are typically male, whilst at the other end of the continuum one finds the gracile opposite, typically female (Figure 1).

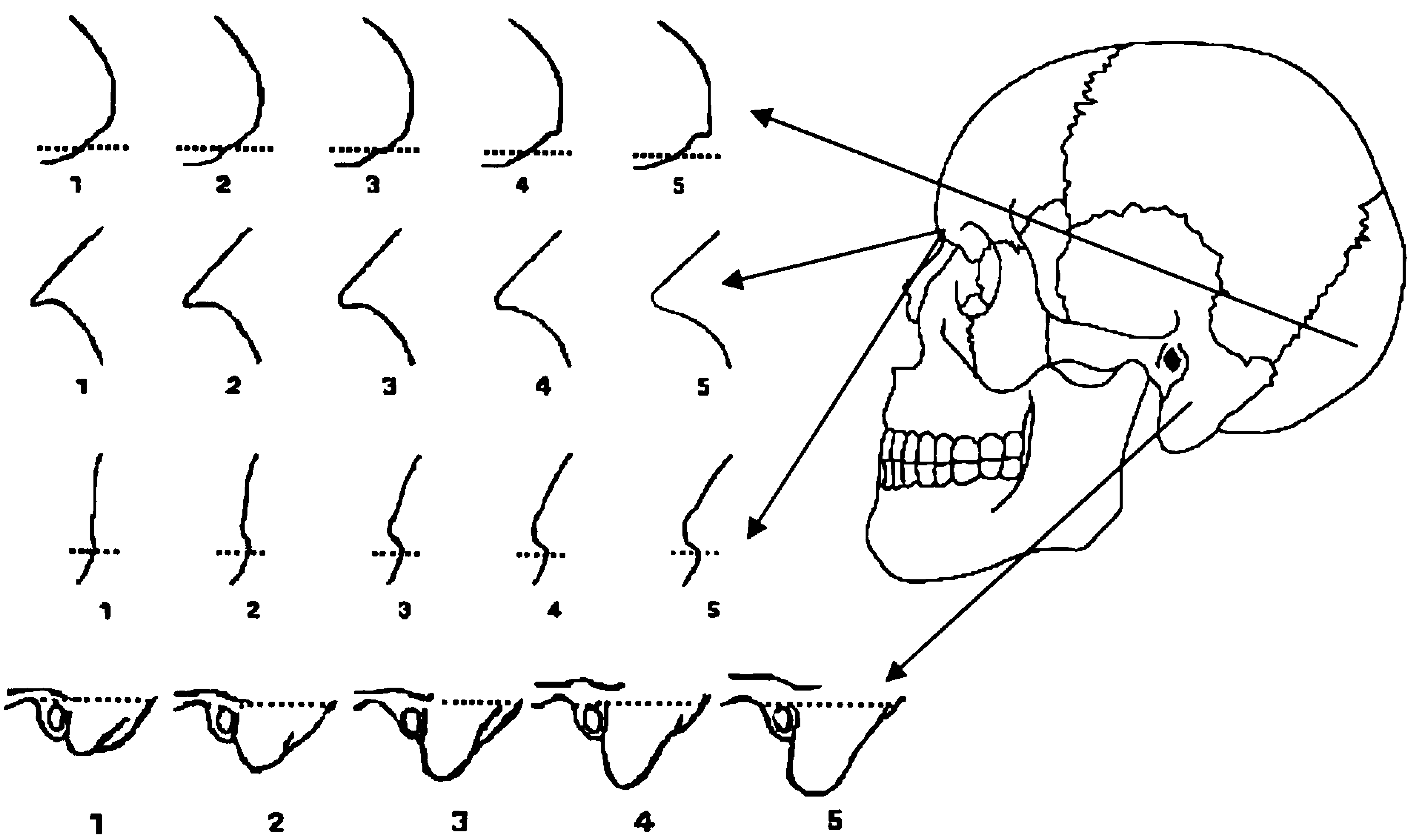

Figure 1- From top to bottom: lateral views of the profile of the nuchal crest, supra orbital margin, glabella and mastoid process. This figures, as well as the correspondent methodological description, can be found in the original manuscript (Acsadi and Nemeskeri, 1970:87-97). The features presently mentioned are only part of the skeletal morphological traits used in sex assessment.

The absence of a methodology to address cases of intersex individuals is an excellent example of bioarchaeologists theoretical, and practical, "entrapment" in the two-sex model, and an indicator of how much of their research in influenced by it: one is either a man or a women. It is, however, fair to say that maybe the non-existence of such a methodology is related to the impracticability of its achievement. That is, if sexing male/female is by itself problematic due to enormous variability of morphological traits, synonymous with the immense human phenotypic diversity, is it possible to scientifically pin-point the boundaries of intersex skeletal individuality?

As briefly explored, one can easily concede that although the majority of methods used in skeletal sex-assessment were scientifically developed, and are therefore quite reliable, the sex-determination of human skeletal remains is not without criticism.

Furthermore, to rely on the sex-assessment of a skeleton to attribute gender to a particular set of grave goods, or to depend on specific grave goods to gender a skeleton, is to oversimplify sex and gender dimensions. It is necessary to keep in mind that sex and gender do not inevitably overlap, or equal each other. Archaeologically it was, and unfortunately still is on some rare occasions, readily perceived that the cultural construction of gender existed inextricably linked to the physical bodies, that is, to the sex of the skeletons (Armelagos, 1998; Lesick, 1997; Mascia-Lees and Black, 2000). Therefore, if the sex of the skeletons is defined based on a supposedly universal sexual biology, gender will follow the same path (Goldstein, 2006; Larsen, 2006). This would disregard to a certain extant, the notion that cultural and social construction of maleness and femaleness could vary chronologically and geographically (Whitehouse, 1998). Furthermore, there are many other cross-gender role categories that do not express the dichotomy based on the universal assumption that a skeleton is either male or female. Since gender is a social, and not a biological construct and, though it may bear some relation with it, the male-female dichotomy implicit in biological sex does not necessarily find its way into culture (Arnold and Wicker, 2001; Grauer and Stuart-Macadam, 1998; Hays-Gilpin and Whitley, 1998b, 1998a; Larsen, 1998; Pollard and Hyatt, 1999). The problems of gendering skeletons, will always have to face the permeability of culture by biology, hence archaeological practice will always be problematic: "while it sets out a theoretical distinction between sex and gender, it simply ends up categorizing people through sex and so returns to biology" (Sofaer, 2006b: 156). The practice of gendering skeletons will always have to make a compromise with the biological nature of the human body.

The strong emphasis placed on the duality of object/body in archaeological practice may produce other questions. For instance, if on the one hand objects in a grave gender a body, on the other hand can the objects themselves be gendered? Even without the action and construction of gender by the individuals who used those same objects (Sofaer, 2006b)? So where does one emphasise gender in bioarchaeology: on the object, or on the body, and which one is more capable of "gendering"? These last questions place both objects and body in a vicious circle. It also translates some of the difficulties of engendering human skeletal material in archaeological contexts. One is forced to ask if in the absence of material culture, is a body "un-gendered"? And on the other hand, is a body (sexed skeleton) enough to convey gender? They both exclude the sphere of performance (Butler, 1990, 1993), one of the major criteria used to define gender, as both object and body are static in the grave. In the absence of performance, is gender possible of being studied?

2.2.3 Are skeletons sexable?

Considering the summary discussion about engendering skeletons based on their sex-assessment, further comments are necessary to clarify the current views on the sexual diagnosis of human skeletal remains. Sex and age at death determination are the central pillars of bioarchaeological study of past human populations, as well as in forensic anthropological analyses. They represent the starting point of all major research and development achievements attained by bioarchaeology. Sex and age at death are both based on the observations of physical skeletal characteristics, and on assumptions that shape, dimension and the macroscopic features of those characteristics are either indicative of degenerative processes, and therefore age-related,[5] or quantifiable as sexually dimorphic.

Sex-determination of a skeleton is primarily done through the analysis of the pelvic bones followed by the cranium. These bones are recognized as the most sexually

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[5] Age at death assessment is conceivably easier to determine in non-adult skeletal material because the methods rely on the ontogenesis of the human skeleton, which has been scientifically ascertained. In adult material age at death is mostly based on degenerative changes observable in the skeleton, specifically in the *os coxae* and cranium. These changes include metamorphoses observable in the auricular surface, pubic symphysis, obliteration of the cranial sutures, wear on the teeth and to a certain extent some researchers also rely on the presence, or absence, of degenerative changes on the joints (Bass, 1995; Buikstra and Ubelaker, 1994; Prokopec and Pretty, 1991; Scheuer and Black, 2000, 2004; Thompson and Black, 2007). Unfortunately, these latter type of degenerative conditions may not be directly related with the biological age of the skeleton, that is consequence of its aging process, but associated with pathological conditions or behavioural modifications (Cox and Sealy, 1997; Ubelaker, 1989). These render these biological parameters less reliable than desired, and their use questionable. Some of the more recent articles addressing age-assessment continue to be built upon the more classic methods of age at death determination. The *os coxae* and cranium are still the more utilized bones (Djuric *et al.*, 2007; Franklin and Cardini, 2007; Igarashi *et al.*, 2005; Martrille *et al.*, 2007; Rissech *et al.*, 2006; Rissech and Malgosa, 2005; Rösing *et al.*, 2007; Schmeling *et al.*, 2007).

dimorphic of the human skeleton. In the absence of both, or either, other bones of the skeleton that have proven to be significantly sexually dimorphic can be used. In these cases the sex assessment is based upon the development of statistical formulas based on the bones' measurements. The bones usually used are femur, tibia, humerus, talus and calcaneus (Alunni-Perret *et al.*, 2007; Bass, 1995; Brickley and McKinley, 2004; Bruzek, 1995; Buikstra and Ubelaker, 1994; Case and Ross, 2007; Celbis and Agritmis, 2006; Gualdi-Russo, 2007; Krogman and Yasar Iscan, 1986; Meindl *et al.*, 1985; Silva, 1995; White, 2000). Ironically, and contrary to age at death, sex is much more difficult to determine in non-adults than in adults. This situation is easily explained, as sex diagnosis is based on the assessment of sexually dimorphic traits that only begin to develop in puberty. The majority of sex diagnosis is based on the observation of minor or major robustness of the morphological traits which are indicative, to a certain extend, of sexual dimorphism. The methods utilize bone measurements which theoretically quantify the robustness of a particular bone, which are then used to classify the specimen according to the method's statistically inferred cut-off points of what is considered robust/male, and what is not (Bass, 1995; Buikstra and Ubelaker, 1994; Case and Ross, 2007; Dar and Hershkovitz, 2006; Franklin *et al.*, 2007; Gauldi-Russo, 2007; Meindl *et al.*, 1985; Rösing *et al.*, 2007; Scheuer and Black, 2000, 2004; Thompson and Black, 2007; Walrath *et al.*, 2004). There are some bioarchaeological methods used to diagnose children's sex. These are based on morphological traits of the mandible and pelvis (Lewis, 2006; Majò *et al.*, 1993; Rösing *et al.*, 2007; Schutkowski, 1993). However, their reliability is questionable. There are alternatives to the morphological analysis of non-adult sex assessment. These are based on DNA and chromosome analysis (Cunha *et al.*, 2000; Lassen *et al.*, 1996; Lewis, 2006; Rösing *et al.*, 2007; Wurmb-Schwark *et al.*, 2007). Sex determination in non-adult skeletal material will continue to be a challenged in bioarchaeology, as much as aging adults' skeletons has proven to be.

Another aspect of sex assessment in adult skeletons that deserves further analysis and discussion is the universality of the sex determination methods used in bioarchaeological research. In the past, bioarchaeologists consistently used the same methods when diagnosing sex. These methods are described in the primary research bibliography used in bioarchaeological studies (Acsadi and Nemeskeri, 1970; Bass, 1995; Buikstra and Ubelaker, 1994; Ferembach *et al.*, 1980; Krogman and Yasar

Iscan, 1986; Ubelaker, 1989; White, 2000). These manuals synthesize the most utilized methodologies in sex and age determination of human skeletal remains. Their international use indirectly ignores the regional variability of human populations. If one uses the same methods worldwide, one assumes that there is no population specific variation in the human skeletal remains. This assumption has been proved to be untrustworthy, as some studies have concluded that population specificity exists (Bidmos and Dayal, 2004; Brasili *et al.*, 2000; Gauldi-Russo, 2007; King *et al.*, 1998). This remark is applicable to many of the bioarchaeological variables used in populational studies (Bocquet-Appel and Masset, 1995; Gauldi-Russo, 2007). A degree of population-specific variation was found to be associated with populational sexual dimorphism variation (Gualdi-Russo, 2007).

There has been a proliferation of studies in which sex and age assessment methods are being developed within regional populations. This is particularly true within the anthropological forensic sciences. A quick search within the articles of two major forensic journals[6] revealed that countries such as Italy, Japan, Canary Islands and South Africa have developed their methods for sex assessment. These will ultimately help to prevent some of the bias introduced by the use of non population-specific methods of sex diagnosis. Furthermore, its applicability to bioarchaeological studies will render population comparisons more realistic. It will also facilitate the assessment of inter and intra population variability more confidently. Finally, if sex and age determination are becoming regional, taking into consideration human variability in their assessment, the archaeological and forensic evaluation of human skeletal remains are a better proxy to past and present realities (Alunni-Perret *et al.*, 2007; Celbis and Agritmis, 2006; Frutos, 2005; Harma and Karakas, 2007; Kyung-Seok *et al.*, 2006). These regional approaches will ultimately eliminate some of the methodological bias existent in sex and age at death estimation, as well as in skeletal ontogeny. Because although scientifically developed, the methods used represented a bias themselves, as they were created and tested in particular samples and populations, and then used as if those population-particularities could be assigned universally. Their general usage in the discipline disregarded existing chronological and geographical regional variations.

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[6] *The Journal of Forensic Science* and *Forensic Science International*.

Another confounding element in the sexing of a skeleton is its aging processes. Older females may erroneously be classified as males, because crania may acquire male characteristics with age due to post-menopausal changes in women. Interestingly, this sex bias may also be a reflection of the *sexism in sexing*, as stated by Phillip Walker, "since the error seems rooted in a cultural stereotype of 'typical' female morphology [rather] than in an appreciation for the complex biological reality of human cranial sexual dimorphism" (Walker, 1995: 36). This *sexism* often leads the ill-advised bioarchaeologist to sex a robust skeletal as male, and a gracile one as female. The assumption that robust bones are male, and gracile bones females is a western cultural perspective. As in reality sex and robustness may not necessarily be synonyms (Gowland, 2006; Walrath *et al.*, 2004). In fact, the robusticity levels found in bones may be the result of biomechanical constraints, and hypertrophy of muscular insertions. As such, these may be related with behaviour and not exclusively with sexual dimorphism (Larsen, 1997; Stock, 2006; Wescott, 2006: to name only a few authors). Furthermore, the degree of robusticity, quantified by bone measurements and indices, may also vary chronologically and geographically between populations (King *et al.*, 1998; Steyn and Iscan, 1999). Consequently, whenever applying a particular method to assess age, sex or other bioarchaeological variable one of the major concerns should be to use the most appropriate method to one's research sample.

Apart from theses methodological issues *per se*, there are also cases were it is impossible to sex skeletal material. In these cases the only alternative is to classify the skeletons as of "sex-unknown" or "undetermined". This situation is particularly related to non-adult skeletal material, damaged, and or incomplete bones, or cremated remains. Some researchers may feel tempted to attribute a sex to these "unsexed" skeletons, particularly if they were found in association with gave goods which are attributed to male or female categories. However, this practice should not be encouraged, and is indeed highly criticised. In such cases, diagnosis can only be made using one's own personal experience and judgment (Claassen, 1992; Donlon, 1993). The criticism of sex assessment also falls within cases where sexual diagnosis is physically possible. Cheryl Classen (1992) has argued quite strongly that the exercise of sex diagnosis of a skeleton is an act embedded with cultural meaning. She states that the assignment of sex to a complete adult skeleton using either implicit or explicit observations is necessarily subjective:

> At the end of the examination, the tally of traits within the male range of variation and the tally of traits within the female range of variation are summed and the percentage of traits typically male, for instance, is used to determine a sex for the skeleton. That a body should be and must be declared either male or female is cultural baggage carried by the investigator. That statistics are used for deciding a sex is cultural baggage (Claassen, 1992: 4).

The critique does not fall on the physical characteristics themselves, but on the "exercise" of sexing a skeleton based on those same traits. This "exercise" as been argued as possessing a socio-cultural dimension (Claassen, 1992). One must recognised that it is true, that a bias exists in the "sexing" of a skeleton. The evaluation of the morphological traits is as dependent upon the method used, as it is on the researcher's experience. Moreover, one must also admit that some researchers may be eager to attribute sex to skeletal remains, when they should not. However, the impossibility of sex-determination may be as important as its determination. These cases may express populational-specific, or individual-specific characteristics that frustrate any positive sex diagnosis. Future bioarchaeological research should acknowledge such situations as these, and view them not as an obstacle but as a challenge to be addressed.

Despite the problems found in "sexing" skeletons, there is factual accuracy in the assignment of sex to skeletons. Regardless of the methodological issues and the researcher bias, a "male" or "female" skeleton will exhibit quantifiable morphological characteristics that are attributable to his/her sex, and are a direct consequence of his/her reproductive ability. With regard to skeletons of individuals who were in life intersexual, current methods, as well as the theoretical approach used in bioarchaeological sex-determination framework, are yet to concentrate on this issue. Currently, the only option is to keep an open mind, and not to be hasty in fixing a skeleton as definitely male, or female.

In conclusion, it can be stated that there are many problematic issues regarding the use of sex or gender in bioarchaeological analysis. The criticism of methodologies in the assessment of pseudo-given biological or cultural characteristics falls into the framework of feminism theorization of social sciences. The inclusion of social science theory in bioarchaeology brings a new and different dimension to the study of human skeletal remains. Human beings are given a chance to provide information concerning their social role, or when already inferred, the new criticism and social sciences allow for a reappraisal of preconceived ideas about past societies. For instance, the integration of social theory in the analysis many aspects of Iron Age and Romano-British communities have proven beneficial in the interpretation of health in these communities (Redfern, 2005). The same conclusion was reached by Rebecca Gowland (2002) whilst analysing age in archaeological contexts, in which biological, chronological and social ages were given similar emphasis allowing for an holistic approach of the life course in Roman-British settlements (Gowland, 2001, 2002, 2006). In the end, regardless of agreement or not with Claassen's (1992) theory of "cultural baggage" associated with sex assignment, in bioarchaeological contexts, one cannot deny the importance of such issues. Her ideas offer powerful and constructive criticism, as they force bioarchaeology to address questions such as the lack of engagement with social theories in their practices (Geller, 2005; Gowland and Knüsel, 2006b; Sofaer, 2006a). Furthermore, they oblige bioarchaeologists to rethink the methods used in sex-determination, as well as adressing many other methodologies employed in the assessment of other bioarchaeological variables.

2.3 Bioarchaeological approach to gender

This section will focus on how the interpretation of human behaviour, through sexual division of labour, can provide a view into gender analysis of past populations. In the context of sexual division of labour, gender assessment on past human populations has been inferred through the analysis of paleopathological changes associated with activity (Hollimon, 1992, 2000, 2001, 2006; Peterson, 1998, 2002). In this context, in order to explore gender, it is necessary to link the biological sources (skeletal material) with the socio-cultural data. An underlying issue surrounding the discussion of sex and gender, and the associated division of labour, is one of nature *versus* culture. Sex and gender issues, born in the midst of feminist theories, are merely one of the frameworks addressing this theme (Geller and Stockett, 2006; Gilchrist, 1999; Hays-Gilpin and Whitley, 1998b; Nelson, 2006; Sorensen, 2000). The importance of discussing the sexual division of labour acknowledging this theoretical framework, relates to the fact that the division of male and females activities have in the past been impregnated with a sense of biological determinism and used to justify sex and gender inequalities.

Where human nature is concerned, it is very difficult to draw a line between nature and culture. One cannot say that biology determines society, because one cannot identify a clear non-social sense of biology, or a biological sense of society. Human individuals stand as the perfect mediator between human biology and social structure (Jaggar, 1997). Understood as such, to convey to *determinisms,* either biological or cultural in matters of human behaviour would be to sacrifice "what makes us human". Hence the importance of biocultural approaches to social sciences.

2.3.1 The biocultural approach: sex, gender and reconstruction of human behaviour

In many aspects of humankind, biology and culture continually interact from birth to death. Therefore, cultural constructs such as gender, or gender-related issues may affect the appearance of the body and ultimately the skeleton (Whitehouse, 1998), and can therefore be inferred through human remains. Furthermore, as with culture, the biology of the skeleton is not fixed: people are born, grow, mature, and senesce (Sofaer, 2006b). Many of those changes are transposed to the social and cultural realm, and used to create categories, such as gender, upon which people expresses themselves according to their bodily experiences. One is even tempted to mention Arnold van Gennep's rites of passage, in which a person's social status is mediated through biological milestones of changes such as birth, menarche, puberty, menopause and death (Gennep, 1960). A person is therefore a product of biology and culture, none of which is deterministic *per se*, but mutually complementary. Hence, bioarchaeology is not about the skeleton, but about the people, of which the skeletons represent the last tangible remains. For example, the presence of traumatic, infectious and degenerative joint lesions, congenital and metabolic diseases in archaeological human skeletal material can undoubtedly be used to map an individual's history, as well as that of a population. In this sense bioarchaeologists can "tell stories". What they must never do, however, is to generate fiction that cannot be supported by the evidence gathered.

There is a growing bioarchaeological literature on this subject of reconstruction of human behaviour, particularly with regard to activity-related osseous changes (e.g. Bridges, 1991; Chapman, 1997; Derevenski, 2000; Jurmain, 1999; Larsen, 1997, 1998, 2002; Pearson and Buikstra, 2006; Peterson, 2002 ; Walker, 2006: amongst many others). The complex interaction between culture and biology is becoming an increasingly important subject in bioarchaeological research (Grauer *et al.*, 1998). Human skeletal remains are not only biological sources of information but most of all they represent biological information integrated within a context. The reconstructions of past social behavior must reflect upon the relationship between biological, social and cultural variables. How their interplay in the shaping of human behavior must be taken into consideration (Walker and Cook, 1998). As such, osteological evidence can be use in the analyses of questions concerning aspects of social organization, social identity and behaviour, based on the assumption that human skeletal remains are not a mere biological source of information, but also represent a source of socio-cultural data (Armelagos, 1998; Bush and Zvelebil, 1991; Larsen, 1998).

The "biocultural approach" tries to understand the relationship between population and culture, and achieves this by answering questions about the general health of population using a variety of data (Bush and Zvelebil, 1991). It deals with the duality of humankind. While it asses the biological condition of human populations and its consequence for the biological and cultural reproduction of society, it also considers the selective effects of society, culture and economy on the population. Hence the biocultural perspective emphasises the integration of data and the relatedness of biological and cultural systems, without attributing a priority to either of them (Bush and Zvelebil, 1991). When analyzing health patterns in past societies, one needs to be aware that the relationship between culture and biology is not necessarily straightforward. For instance, when health is evaluated by cultural perceptions and parameters, illness and disease are, or can be, a culturally defined phenomenon. That is why it is so important to consider both perspectives (biological data as well as cultural data) in the study of health in the past, as well as in present societies (Bush and Zvelebil, 1991; McElroy and Townsend, 1996). On the one hand social categories, such as status, are constantly used to trace populational profiles of health. On the other hand, populational profiles of health can also be used to assess social categories. For instance, higher social status "conferred" on skeletons based on their burial context is usually corroborated by, or inferred through, the analysis of nutritional deficiencies or other pathologies thought to be indicative of differential social status (Groves, 2006; Pechenkine and Delgado, 2006; Redfern, 2005; Robb *et al.*, 2001; Sullivan, 2004; amongst many others).

The assessment of health based on skeletal remains also needs to acquiesce that multiple diseases can lead to similar signs or bony reactions in osteological material, making it very difficult to pinpoint the specific causes behind the skeletal changes (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003; Roberts and Manchester, 2005; Zimmerman and Kelley, 1982). Furthermore, because the skeletons, or bones, are the last system of the organism to be affected by a disease, or a situation deleterious to health, skeletons may not exhibit all the signs to which an individual was subjected. In fact, a person can die without displaying any evidence of the diseases, or health challenging events from which he or she may have been subjected too. Skeletons may not be as representative of life hazards as previously thought, however appealing such scenarios may have been in the past. The question of precisely how representative an individual's skeleton may be in assessing health status or relevant population, is one of the most puzzling, and interesting subjects discussed in bioarchaeology. This was systematized and discussed by Wood and colleagues (1992) in what became known as "The Osteological Paradox". This theme is still an issue in contemporary bioarchaeology, and still demands further study (Wood *et al.*, 1992; Wright and Yoder, 2003)

If health is a measure of fitness, and it influences our social and biological reproduction ability, it is therefore a central piece to our understanding of human biological and cultural development. However, because the concept of health may be differently understood cross-culturally, it is only at the interface of archaeology, culture and bioarchaeology, and within the framework of the biocultural approach, that the study of health in past societies is achievable (Bush and Zvelebil, 1991; Woods *et al.*, 1992).That is why exploring the biocultural relationships of past populations places bioarchaeology at the centre of such areas of study. Skeletal remains may not provide a direct information about culture, but they may certainly shed light on people's health histories, some individual experiences and, indirectly, social relationships.

With a "biocultural perspective" the function and value of males and females in society can be explored. Different impacts on men and women due specific cultural, social and behavioral factors can be decoded with reference to gender. Consequently, when studying sex-related health differences one must also consider gendered-related health differences (Larsen, 1998; Roberts *et al.*, 1998). Behavioral differences that are gender-based may be used to infer a populational pathological profile, and activity-related osseous changes found in skeletons may be used in this exercise (Armelagos, 1998; Derevenski, 2000; Peterson, 1998, 2002).

In past populations, the division of labour is theoretically believed to provide a link between the social construct of gender, and the impact of work on the skeleton. Hence, the concept of gendered division of labour, as a variable that can be used when comparing sex differences in activity-related osseous change, has been employed as a theoretical model to assess gender differences through paleopathological analysis (Grauer and Stuart-Macadam, 1998; Peterson, 2002). However, whether this is possible is debatable. This matter will be addressed in the final discussion of this research.

As bioarchaeologists begin to understand how behaviour affects the skeleton, and how gender affects behaviour, the distinctions between sex and gender are of enormous interest and significance (Armelagos, 1998; Geller, 2005; Grauer *et al.*, 1998; Hollimon, 2001, 2006). By exploring these two notions, bioarchaeologists are able to raise new questions. Most importantly they give a new meaning to the exercise of sex attribution. It is therefore necessary to pay attention to all available information whilst sexing a skeleton. This is especially the case when the aim of the study is to infer the social milieu from which that skeleton was retrieved. A multidisciplinary approach is likely to be the most effective way of studying gender in archaeological contexts. This is particularly so since gender may manifest itself differently in different groups according to the "activity" performed, whether social, economic, ritual and other (Vida, 1998). Studies which bring together a serious and systematic correspondence between bioarchaeology and material culture might triumph in showing new, and more accurate, perspectives in exploring variability in human behaviour (Vida, 1998).

2.3.1 Use of skeletal remains in the interpretation of sexual division of labour

How does one use the sexual division of labour to study gender through human skeletal remains? One does so based on the assumption that gender leaves traces in the archaeological record. These traces are not only in the material culture associated with the burials, but also to be found in the bones themselves. In the latter case, the "mark" of gender upon the bones would be done as an expression of behaviour, and ascertained through the use of what is commonly know in bioarchaeology as *markers of occupational stress* (MOS) (Capasso *et al.*, 1998; Jurmain, 1999; Kennedy, 1989; Larsen, 1997, 2000, 2002; Wilczak and Kennedy, 1989). The observation of pathological differences in the human skeletal remains of male and females, allows for gender inferences to be made, particularly in the identification of differentiations based on the sexual division of labour (Holden and Mace, 1999). This is based on the hypothesis that sexual division of labour is intimately related with sex, male or female, which can be diagnosed in the skeletons. As men are perceived as stronger, they would presumably perform more strenuous and daring tasks, whilst females, automatically presumed weaker, would be limited to housework, and far less physically demanding occupations. This overall pattern of social organization has been extensively discussed under the banner of gendered hierarchies (Leibowitz, 1986; Peterson, 2002; Watson and Kennedy, 1998; Whitley, 1998). However, accounts of sexual division of labour may have over-simplified the relationship between sex and gender, as well as the organization of society based on labour differences. There exists a tremendous variation in sex/gender labour division which is absent, or poorly treated in most accounts of past societies, as well as ethnographic records (Gilchrist, 1999; Watson and Kennedy, 1998). Furthermore, past societies may not necessarily have shared the western notion that females would be lesser, or weaker, than men. Particularly if that notion of weakness is associated with work being performed within the household in domestic-related chores, gathering or processing food. This is basically a western, and very contemporary point of view (Hurcombe, 1995).

The framework of sexual division of labour, gender hierarchy and gender inequity, has produced two models which summarize the polarized view of male and female differences. One is based on the male dominance of society and of social knowledge; the other emerged as a critique to the first, in the realm of feminism theorization. The first is known as the model "Man-the-Hunter" model, and the latter as "Women-the-Gatherer" model. They both represent a particular perspective on the evolution of human societies, and on the importance of women and men in its development. The first emphasises men as being responsible for the development of human history, and its evolution, while the second gives women a more relevant role in the emergence of humanity (Di Leonardo, 1991b; Fedigan and Fedigan, 1989; Gilchrist, 1999; Nelson, 1997; Tanner and Zihlman, 1976; Zihlman, 1978, 1989). Man-the-hunter model implied the assumption of rigidity in the sexual division of labour, resulting in the sexual association of activities – task differentiation (Conkey and Spector, 1984). These "task differentiations" would be intrinsically correlated with biological size and strength differences between male and female, based on the sexually dimorphic characteristics of the individuals. This scenario was presented in an evolutionary perspective, from early hominid until the present time (Leibowitz, 1986). In this sense, the sexual division of labour would be "protocultural", intrinsic to nature and produced along the sex lines naturalizing male and female inequalities (Gero and Conkey, 1991; Leibowitz, 1986). Ultimately, all human social inequities were based and promulgated on the basis of human biology (Strickland and Shetty, 1998).

New gendered approaches have begun to dismantle these universal and evolutionary models of sexual division of labour (Gilchrist, 1999). Research has demonstrated that there is an enormous cultural diversity in female and male tasks (Derevenski, 1997).

Ethnographic studies are showing a complexity and wide cross-cultural variability in gender arrangements in living societies (Conkey and Spector, 1984). Gender may not only vary from culture to culture, but it can also vary independently, i.e. sex roles and gender ideology are not necessarily congruent within a given culture (Conkey and Spector, 1984). Most importantly is the recognition that the derogatory emphasis given to tasks, such as gathering, is a mere reflection of today's preconceived ideas of what is manly or feminine, all associated with the latter category being a synonym for weakness and compliance (Wadley, 1997; Wright, 1991).

The final conclusion is that regardless of the "sexual-division of labour" model chosen, either Man-the-Hunter or Women-the-Gatherer, the interpretation of behaviour of past human societies was/is perceived through the analysis of human skeletal remains. In the specific case of portraying *Gender* in bioarchaeological studies, this is thought attainable using skeletal markers of occupation which are considered to be intrinsically related to occupational tasks performed by individuals. In the end, if gender restricts the behaviour of men and women, as social individuals, it would also interfere with the activities performed resulting in different "marks" on the skeletons. The sexual division of labour is one of the platforms of performance in which differences between men and women can be explored. With this in mind, one can explore how male and female patterns of markers of occupational activity vary, and if there are any tasks, or activity-specific patterns observable in the skeletal markers. The existence of a pattern, or lack of it can, be related with gendered division of labour. The approach to gender based on markers of occupational stress (MOS) will be properly explored in the following chapter.

Chapter 3: Gendered Bone. A Paleopathological Perspective

The aim of the present chapter is to contextualize the use of gender in paleopathological analysis. Firstly, a brief reflection on the concept of gender in bioarchaeological studies, as well as the introduction of the methods used to asses' gender in bioarchaeological contexts, will be addressed. The referred methodology to address gender in bioarchaeology will focus only in the analysis of markers of occupational stress (MOS). Secondly, an overview of MOS and their progression in bioarchaeological studies will be discussed. A critical review of the most updated, and classical literature will be provided. Thirdly, a summary introduction to the MOS used in the present research will be conducted. For each MOS employed in the current research, definitions of each, a brief discussion of the methodologies, and their importance and relevance in today's bioarchaeological research will be outlined. Finally, a summary of the main points of the chapter is provided. The end section of this chapter is brief list of bioarchaeological studies done within the context of MOS. These studies are representative of the overall approach to activity on human skeletal material.

3.1 Gender and Palaeopathology

Interest in gender studies in bioarchaeological research has increased after the published works of Walker and Cook (1998) and the book edited by Grauer and Stuart-Macadam (1998). The first was a brief communication on *Gender and Sex: Vive la difference*, and the latter a book entitled *Sex and Gender in*

Paleopathological Perspective. They both address the distinction of sex and gender terms in paleopathological analysis as an important issue. They referred to the overall misuse of sex and gender as interchangeable concepts in the biomedical literature, despite the overall awareness of its difference.

> There is a consensus in anthropology that sex is defined by the biological differences between males and females determined at the moment of the conception and enhanced in subsequent physiological development. [...] There is also agreement that gender is the cultural construct in which individuals are socially classified into categories such as male and female, or masculine and feminine in our culture (Armelagos, 1998: 1).

The reasons cited for the misapplication of sex and gender terminologies, as quoted by George Armelagos (1998: 1-2) are those of political correctness, researcher experience or even theoretical background. For instance, someone with a background in social sciences would easily recognize the implications of using sex and gender as synonyms, when compared to a researcher with a background on biological sciences. Despite this overall awareness of "distinction", in modern western society gender is commonly used as an identifier of biological sex. In their article, Walker and Cook analysed of the use of sex and gender in the biomedical literature between 1966 and 1995. They found an increase in the use of sex and gender as equivalents in the last decade, with "physical anthropologists" amongst the worst offenders (Walker and Cook, 1998: 257). These findings somehow contradicted the "consensus in anthropology" that sex and gender refer to different categories of the human life, as referred to by Armelagos (ibid.). It also underlines the necessity for a stronger promotion of the differentiation between sex and gender in bioarchaeological studies. The cited authors all share the opinion that it is necessary to preserve the intrinsic meaning of sex and gender throughout any analysis, or research based on the assumption that men and women, as biological and socio-cultural entities, experience life differently:

> In many areas of physical anthropological research, and especially in bioarchaeology, maintaining this distinction is important because it makes it possible to explore the relationship between the biological and social forces that shape human behaviour. Failure to make a distinction between gender and sex will seriously hobble

communication with other branches of our discipline. Vive la difference! (Walker and Cook, 1998: 259)

In bioarchaeology one can pursue the basis for gender analysis by: firstly sexing the skeleton; secondly, by attributing sex-related activities to a particular gender, on the supposition the these sex-related activities would embrace certain behavioural patterns; thirdly, that these gender-related behavioural patterns would produce differential pathological patterns of activity-related lesions on the skeletons; and finally, that these activity-related lesions would be usable to assess behavioural differences that are gender related. It is precisely in these last steps that a liaison between palaeopathology and gender is established. The rational is that gender is expressed thought the differential pathological patterns of activity-related lesions on the skeletons.

Behavioural gender-based differences can affect a population's pathological profile. For instance, in a population where the access to resources by males and females is different, divergent patterns of diet-related pathologies are expected to be found between individuals of different sexes. Amongst the several pathological lesions associated with diet intake insufficiencies we find enamel hypoplasias the most commonly used (Cucina and Iscan, 1997; Knudson and Buikstra, 2007; Palubeckitė *et al.*, 2002: to name only a few studies). Hence a paleopathological perspective on gender will necessarily focus on pathological differences between men and women, which can be indirectly linked with their social category - gender. Some of those pathologies are related with the sexual-division of labour, or preferably, activity-related differences between men and women, in which daily-life activities were taken as proxies for the social sexual-division of labour. This is precisely the underlying assumption of the paleopathological approach to gender in this research: that gender can be inferred through pathologies related with occupation.

Paleopathologically, the bone markers which have been systematically associated with occupation and physical activity are universally denominated as Markers of Occupational Stress (MOS) (Capasso *et al.*, 1998; Jurmain, 1999; Kennedy, 1989;

Larsen, 1997, 2000, 2002). MOS include enthesopathies,[7] degenerative changes in the articular surfaces; trauma,[8] amongst them stress fractures,[9] such as spondylolysis; Schmorl's nodes; tibial periostitis; structural adaptation of bone: and functional morphological variations (non-metric traits). These are the osseous markers commonly used under the umbrella of MOS, and utilized when attempting the reconstruction of past human behaviour (Capasso *et al.*, 1998; Jurmain, 1999; Kennedy, 1989; Larsen, 1997).

The use of activity as a mediator of gender in human skeletal remains presumes, as already discussed in the previous chapter, that gender is easily identifiable from human skeletons, as the latter are easily sexable and the sex of an individual is "nearly always revealing about their gender [hence] the jump from sex identification to social identity and behaviour inferences is not a big one" (Larsen, 2002: 145). This simplistic affirmation, easily accepted in many bioarchaeological studies, is not as straightforward and reliable as previously thought. As already explored in Chapter 2, sex and gender do not necessarily overlap in archaeological records. Based on this irrefutable fact, the statement made by Larsen (ibid) is, if nothing else, controversial. Nevertheless, and from a bioarchaeological generalist perspective, men and women do perform different activities (either occupation related or not), and it is commonly accepted that these can be inferred from their skeletons using MOS (Capasso *et al.*, 1998; Kennedy, 1989; Larsen, 1997, 2002). However, in more recent years this approach to human behavioural reconstruction has been debated, and the urgency to address underlying methodological and theoretical problems has become one of the major concerns of the bioarchaeological discipline (Jurmain, 1999; Pearson and Buikstra, 2006; Waldron, 2001).

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7 These are distinctive markings that occur on points where muscles, tendons or ligaments insert into the periosteum and underlying bony cortex (Hawkey and Merbs, 1995; Knusel, 2001). They are believed to result from repeated trauma, or as a consequence of regular muscular exertion that results in hypertrophy of the bone at that area in the form of rugged muscular attachment. The concept of hypertrophy of insertion sites in response to activity relies upon the evidence that mechanical loading, direct or indirect, may lead to bone hypertrophy (Wilcazak et al., 1998).

8 Some traumatic lesions provide unambiguous evidence of behaviour, especially relating to interpersonal aggressions (Jurmain, 1999).

9 Stress fractures are in many cases "clinically documented to occur in context of over use. Moreover, at least two osteological manifestations, so-called clay – shoveller's fracture and, especially spondylolysis, are well-established to be associated with activity." (Jurmain, 1999: 169).

In 1994, Tony Waldron commented on the actual state of the art of MOS in bioarchaeological research. In *A Question of Occupation* (p.92-101) he summarized some of the major problems encountered in the assessment of activity-related skeletal changes, and occupation in human skeletal remains. Although the chapter addresses osteoarthritis particularly, the issues raised can easily be extrapolated to the remaining skeletal changes used to assess occupation and activity in bioarchaeological context. Some of the issues addressed by the author were not a novelty; however, his view of the overall use of diseased joints and other skeletal pathologies illustrated the two polarized views that dominate the scene of MOS in bioarchaeology. On one side, there exists the notion that biological, as well as human social behaviour, is readily available through the analysis of human skeletal remains; on the other, we find "those who consider that there is virtually nothing which can be gained from the examination of skeletons" (Waldron, 1994: 92). Presently, the criticism voiced in this statement specifically targets the methods used in the assessment of these MOS (as will be discussed later in this chapter). Whether or not MOS can genuinely represent activity-related changes, needs to be further discussed and tested. The third possibility presented by Waldron relates more closely to the position adopted in the current work. The results based on the MOS analysis were addressed conservatively, and with a strong emphasis on a constructive criticism.

The current research began with the firm belief in the possibility of assessing behaviour, and ultimately gender, throughout paleopathological analysis. It would do so by utilizing the MOS referenced in the overwhelming amount of published articles and books (cited above). After further and careful examination of such publications, and as a result of the analysis and testing of the skeletal data, it became noticeable that the possibility of portraying gender through a paleopathological perspective may not be practicable. It was, however, extremely interesting to discover that the use of MOS is still very much alive in bioarchaeological contexts and that, with rare exceptions, a constructive criticism is seldom seen.

Despite the overall issues raised in MOS analysis, as long as bioarchaeologists are aware of the method's limitations, and of the variability of skeletal response to pathology and/or stress, a reasonable and educated picture of past populations can be inferred. What one should avoid is the articulation of "extravagant claims [...] about environmental stresses, parity, social status and occupation or occupationally related activities" (Waldron, 1994: 92). Future bioarchaeological studies on MOS need to consider the limitations as well as advantages of the methods currently employed in their assessment.

3.2 Markers of Occupational Stress (MOS)

Sarah Groves (2006) stated that the original reference of the term markers of occupational stress (MOS) is attributed to Francesco Ronchese (1948),[10] and has since been used extensively in the field of interpretation of human behaviour in bioarchaeology (Groves, 2006). However, interest in the human skeleton as a palimpsest of life habits, by anatomists and surgeons, dates back to the 16th century,[11] with an increased interest during the nineteenth century (Kennedy, 1989; Wilczak and Kennedy, 1989). A more recent summary of the roots of behaviour, and activity assessment on bones has been published by Osbjorn Pearson and Jane Buikstra (2006). The authors provide more than a descriptive overview of the use of MOS in the reconstruction of behaviour; they also convey the idea that MOS are currently in the crossroads of criticism and change. There is an emergent awareness of the importance of acknowledging confounding variables in the assessment of behaviour in bones, which was either overlooked or minimized in past studies; as

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[10] The types of occupational markers addressed by Ronchese were physically visible ones such as discoloration, pigmentations and callosities in the nails, palms and skin surface, contrary to the counterparts assessed in bioarchaeology. The examples given are detailed: for instance gunpowder workers, silversmiths, photographers and cobblers would posses specific discolorations of the hand; jeweller, engravers, ring maker, and others similar artisans would have characteristically large and heavy calluses in the centre of the right palm, due to the constant use of pliers; a florist would have deep cut and scratched fingertips from the use of wires, and heavy shear callus on the right middle finger, similar to the ones of a tailor; and barbers would easily have calluses on the thumb, right index and middle and ring fingers from the scissors (Ronchese, 1948: 8, 16, 17).

11 Kenneth Kennedy referred to Georgius Agricola's (1494-1555) posthumous publication of *De Re Metallica* (Of Metal Matters) in 1556. It concerns a systematic examination of mining and metallurgy as practiced in the sixteenth-century mining centre of Joachimsthal in Czechoslovakia. The Work comprises 12 volumes, in which Agricola explored the mining operations, as well as its ill effects on miners (Weber, 2002).

well as the consciousness of the need to improve both recording methods, as well as analytic procedures (Jurmain, 1999; Pearson and Buikstra, 2006; Wilczak and Kennedy, 1989).

The acknowledgment that bones and behaviour may not be as straightforwardly correlated as expected, may be problematic. This is particularly true if one considers the significant number of publications on the subject, particularly the ones re-vindicating a strong correlation between occupation, or activity-related patterns and MOS. Despite the general awareness of this problem, one cannot deny the relevance and the importance of the contribution made by past research on this subject. The development of systematic observation of occupational markers has been particularly prolific since the earlier 1990s, and since 1995 there has been a large increase in their use to portray human behaviour (Jurmain, 1999; Pearson and Buikstra, 2006), including a special issue on stress markers by the *International Journal of Osteoarchaeology* in 1998 (Volume 8, Issue 5).[12] Wanting or not, MOS research was, and is, one of bioarchaeological avenues of inquery (see section: Bioarchaeological studies on MOS, in the end of this chapter).

Markers of Occupational Stress have already been extensively explored in books and articles published by Robert Jurmain, Clark Spenser Larsen and Kenneth A. R. Kennedy, amongst many others. The contextual use of MOS has been that of changes in subsistence economies (hunter-gatherers *versus* agriculturalist), pre and post-contact populational relations (such as those of pre- and post-European contact in North America), as well as in the context of specific occupations (i.e. occupation=specific task) (Cohen and Armelagos, 1984; Goldstein, 2006; Jurmain, 1999; Larsen, 1997, 2000; Pearson and Buikstra, 2006; Stirland, 1993; Waldron, 2001: amongst many others; Weiss, 2005). In the particular context of "specific tasks," the functional morphological variations are singularly associated with precise

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12 The papers condensed in this special Issue include some originally presented in a symposium entitled *Activity Patterns and Musculoskeletal Stress Markers: An Integrative Approach to Bioarchaeological Questions*, 1997. The symposium was presented at the Sixty-sixth Annual Meeting of the American Association of Physical Anthropologists, in St. Louis, Missouri, on April 4, 1997 (Peterson and Hawkey, 1998). This issue is mostly composed of articles that particularly address the use of musculoskeletal stress markers, commonly known as enthesopathies, in the assessment of behaviour. Musculoskeletal stress markers should not be confused with MOS, as they are only one of the parameters/bony changes representative of MOS.

activity types, such as squatting and kneeling, reflecting habitual postures that can be mechanically demanding and/or repetitive, and ultimately used to identify accurate behavioural habits (Boulle, 2001; Capasso *et al.*, 1998; Kennedy, 1989; Larsen, 1997; Ubelaker, 1979). Other examples commonly given are that of the Poirier's facet, and the extension of the distal epiphysis of the metatarsals (Capasso *et al.*, 1998; Larsen, 1997). However, once more, these skeletal markers must be assessed and interpreted carefully, and always within their original context.

One of the major problems/criticisms in the assessment of occupations using MOS is methodological, and this issue ties in perfectly with the lack of comparative clinical data. This is particularly true as there is a lack of bioarchaeological research done in conjunction with clinical investigation. Many of today's assumptions concerning MOS, and occupation/activity-related lesions still rely on methods and concepts developed either in the beginnings of paleopathological analysis, or in the late 1980s. These ignore much of the new medical and technological advances, as well as new epidemiological, and clinical information regarding the aetiologies of the pathologies grouped under the umbrella of MOS. The "single cause-effect" of skeletal changes is out of date, and one needs to consider the overall plethora of causes in the development of the so called MOS (Jurmain, 1999; Waldron, 1994, 2001; Wilczak and Kennedy, 1989).

Whilst one waits for the "methodological revolution," and in the absence of communal research between bioarchaeology and clinicians, an holistic perspective on MOS is the safest approach to reconstruct past population behaviour. This approach would combine both biology and culture as having predominant roles in the interpretational outcome of human behaviour/occupations (Jurmain, 1999). The biological data is interpreted within its historic, geographic and cultural contexts (Jurmain, 1999). Additionally, if instead of analysing each activity-related pathological change individually, they are "pooled" together, given a more complete and complementary analysis of a skeleton, the overall assessment of the health status of the individuals, and ultimately of the population is better achieved (Jurmain, 1999). For example, the analysis of osteoarthritis in conjunction with muscular changes, in a particular joint, may provide a better context for hypotheses testing. Furthermore, the acquiescence that culture may play a part in the development of specific skeletal changes, either due to cultural beliefs, changes in subsistence economies or as a result of contact with new/other populations, may help to better understand the patterns of changes observed in bones. Most importantly, without the cultural dimension in bioarchaeological analysis, inferences on gender (as well as other cultural/social variables) may be a pale reflection of the vivid reality.

The ideal circumstances to assess MOS, as referred to by Jurmain (1978 in Wilczak and Kennedy, 1989: 464-465) would be a "situation where an adequate sample is represented, where parameters of sex and age are controlled, and where the population samples are relevant to clearly identify hypotheses about category of diseases which might be identified in the sample." The authors added that

> the perspective provided by archaeological skeletal series can add a significant time dimension as well as include geographically separate communities with contrasting life-styles. [...] When age, sex, endocrine factors, timing of onset on skeletal changes and ancestral background can be accurately determined, then greater reliability of correlating morphology with behaviour is gained (Wilczak and Kennedy, 1989: 465).

The authors additionally referred to other criteria favourable to accurate MOS observation and identification: knowledge on the specialized activities present in past populations; full recovery of the human remains from the burial context; and full understanding, and recording of the burial context itself; as well as excellent material preservation, and evidence of cultural and genetic isolation (Stirland, 1991; Wilczak and Kennedy, 1989). However, this ideal situation is rarely, if ever, achieved in archaeological samples.

In conclusion, and as mentioned by Jurmain (1999), one important aspect to be taken into consideration in future attempts to reconstruct behaviour of past societies, is that none of the MOS results directly, or simply, from activity alone (Jurmain, 1999). Nevertheless, an insight into past populational behaviour can be glimpsed. The only way to overcome the weak specificity of individual osseous markers is to use a multiple indicators strategy. Each one of the osseous markers can ostensibly provide some evidence of activity. It was therefore intended to aim for an "holistic" approach in order to reconstruct behaviour in the populations in this research.

3.2.1 Osteoarthritis (OA), Musculoskeletal Stress Markers (MSM), Cross-Sectional Geometry (C-SG) and external diaphyseal measurements (EDM): Leading roles in the assessment of activity-related changes in the skeleton

The markers which constitute the conventional approach to the study of activity-related changes are degenerative joint diseases, frequently and simplistically referred to as osteoarthritis (OA); musculoskeletal stress markers stress (MSM); and cross-sectional geometry (C-SG) which replaced the more classic external diaphyseal measurements (EDM) of long bones. Briefly, OA[13] is the most common joint disease in both modern and ancient populations (Rogers and Waldron, 1995). It is a pathology that affects the synovial joints,[14] and is mostly characterized by loss of articular cartilage and subsequent bone reaction of the subchondral and marginal bone (Rogers and Waldron, 1995: 32); MSM were defined by Diane Hawkey and Charles Merbs as "a distinct skeletal mark that occurs where a muscle, tendon or ligament inserts onto the periosteum and into the underlying bone cortex" (Hawkey and Merbs, 1995: 324). The "distinctive mark" has bioarchaeologically been defined as enthesopathy. This implies that an ossification has extended from the bone into the

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13 Several publications have addressed the issue of whether to denominate the disease as osteoarthritis or osteoarthrosis. The first imputes joint disease to primary inflamation conditions, and the second to mechanical factors. An alternative term was suggested "Degenerative Joint Disesase"; however, this one has also been criticized since the word "degenerative" would emphasise on the importance of age in the onset of the disease (Jurmain, 1999; Radin, 1993). In the current research the term OA will be use to refer to the degenerative joint disease found in the diarthroses. It will include the several degenerative bony changes associated with joint pathology such as marginal lipping, osteophytes on the joint surfaces, porosity and eburnation.

OA is classified as idiopathic or primary, when there is no other known medical cause or event responsible for the pathology, such as a traumatic episode, and secondary when the later occurs. Idiopathic OA has multifaceted aetiological factors including genetics (inherited disorders, mutations, population specificities), non-genetic host factors (increased age, obesity, sex-specific such as post-menopausal state), environmental factors (occupation, physical activity due to leisure or sport) may act together or separately in the development of OA (Creamer and Hochberg, 1997; Doherty *et al.*, 1983; Sokoloff, 1969). But even a simplistic classification as this, idiopathic versus secondary, may fail to represent the reality of the disease, as pointed out by Doherty and colleagues (1983). A person may have an inherited predisposition to develop the disease but its development will only occur when allied with other factors, such as biomechanical insult (such as a knee injury) (Doherty *et al.*, 1983; Felson *et al.*, 2000). Another factor to consider is the distribution of the disease, if local it may bear a closer relation to confined (mechanical) factors, whilst if generalize it may be indicative of a genetic predisposition (Spector *et al.*, 1996).

14 Diarthroses are mostly known as synovial joints due to the layer of synovial fluid found between the two articulating surfaces of the bones. The articulating ends are covered with articular cartilage, surrounded by the synovial membrane and a joint capsule of ligaments. Other joints, such as the knee may have an additional disc of fibrocartilage called meniscus with the function of better distributing mechanical forces and protect the bones (Freivalds, 2004: 47; Gunn, 2002; Wright and Radin, 1993)

regions of the tendon and ligaments, at their attachment site (Shaw and Benjamin, 2007). Cross-sectional geometry reflects the amount and distribution of diaphyseal cortical bone within a specific cross-section of a bone. It measures the amount of bone in the cross-section and includes the total subperiosteal area, medullary area and cortical area (Bice, 2003: see this thesis for a more extensive overview). The external diaphyseal measurements are usually taken at the medial-lateral and/or anterior-posterior diameter of the bone's diaphyses (Bice, 2003); however, length and other epiphyseal measurement may also be taken (Bass, 1995; Buikstra and Ubelaker, 1994; Wescott, 2001).

The use of OA, C-SG and MSM in archaeological analysis of human remains has been based on the assumption that mechanical loading on the joint, entheses and long bones bear a relation with physical-activity. These MOS would express activity-related osseous changes either caused by stress due to repetitive mechanical load, or as a by-product of traumatic events (Jurmain, 1999; Kennedy, 1989; Larsen, 1997; Rogers and Waldron, 1995; Wilczak and Kennedy, 1989). Consequently, they could be use as surrogates in the quantification of the amount, and severity of work an individual would have performed. Major differences would be expected between men and women, particularly in populations representative of transitional periods, such as hunter-gatherers to agriculturalist, as a strong and distinctive sexual-division of labour would be expected (Cohen and Armelagos, 1984).[15] This optimistic view, that MOS can be used to reconstruct behaviour, has increasingly become substituted by a more conservative and cautionary perspective. Currently, sex, age, diet, hormonal levels, genetics and anatomical morphology are known to influence the outcome of OA, MSM and bone structure and morphology. Hence the assumption that mechanical load can be solely responsible for any of the above mentioned bony changes needs to be thoroughly tested. In fact, the "sole activity-related explanation" is one of the major criticisms of the MOS line of inquiry. It disregards the complex aetiology of almost all of the MOS in question, as already mentioned (Jurmain, 1999; Wilczak and Kennedy, 1989).

15 The work published by Mark Nathan Cohen and George J. Armelagos (1984), about palaeopathology at the origins of agriculture, is an excellent example of the past importance of OA in the reconstruction of human behaviour. Successive research on the subject of changes in subsistence economies, or in the use of OA as a markers of activity, has consistently refer to this publication and its authors (Jurmain, 1999; Larsen, 1997).

In the next sections, OA, MSM and C-SG will be addressed separately as to better discuss some of the current issues underlying their research. Most of the issues criticized in each, are common to all. However, there are singular points that justify their individual approach. Firstly an overview of the methods used to assess these particular MOS will be described. Secondly, the major methodological problems will be discussed, and finally a brief discussion of their importance as activity-markers will be addressed.

3.2.1.1 Osteoarthritis (OA): An overview

OA is only accessible in bioarchaeology when there are bony manifestations in the synovial joints that are traced back to the pathology. Other symptomatic traits of OA, observable in living individual, such as pain, swelling and joint stiffness, are intangible in the skeletal remains. Hence, the diagnostic criteria used in clinical and biological contexts are distinct, although they can overlap when distinctive bony lesions are present, particularly osteophytes.

Clinically, OA is characterized by joint pain, tenderness, limitation of movement, crepitus, occasional effusion, and variable degrees of local inflammation. Histologically, the disease is characterized early by fragmentation of the cartilage surface, cloning of chondrocytes, vertical clefts in the cartilage, variable crystal deposition, remodelling, and eventual violation of the tidemark by blood vessels. Pathologically, OA corresponds to focal areas of loss of articular cartilage within synovial joints, associated with hypertrophy of bone (osteophytes and subchondral bone sclerosis) and thickening of the capsule, as well as joint space narrowing. Theses changes can be assessed by the use of imaging techniques, such as radiography amongst others (Altman and Gold, 2007; Cicuttini *et al.*, 2003; Felson *et al.*, 2002; Lane *et al.*, 2004; MacGregor *et al.*, 2000; Nagaosa *et al.*, 2002; Oka, 1999; Ozdemir *et al.*, 2006). Systematic clinical criteria for OA diagnosis were developed for the knee, hip and hand (Altman *et al.*, 1991; Altman *et al.*, 1990;

Altman *et al.*, 1986; Kellgren and Lawrence, 1957a). The radiographic scoring system systematized by Kellgren and Lawrence (1957), was one of the first developed, and is still in use today, although other scoring systems have been created since (Altman and Gold, 2007; Spector *et al.*, 1993). Radiographic scoring systems are still the major tool in the clinical diagnosis of OA.

Despite the resources available, OA diagnosis in clinical context is not as clear cut as it would first appear. In fact, clinical symptoms may correlate poorly with the presence of radiological features of OA, such as osteophytes or joint space narrowing. Their radiological evidence is not necessarily symptomatic, and pain, swelling and joint stiffness may not be related with any bony change (Hart *et al.*, 1991; Jones *et al.*, 2004; Lachance *et al.*, 2001; Link *et al.*, 2003; Oddis, 1996; Petersson and Jacobsson, 2002; Zhai *et al.*, 2007). Furthermore, the quantitative techniques available for diagnosis, such as radiography, CT-arthrography, ultrasonography and MR imaging, may fail to detect subtle cartilage and bone abnormalities found in early onset of OA (Cicuttini *et al.*, 2003; Hodler and Resnick, 1996).[16] Hence, the ideal situation for the study of OA combines the use of both imaging techniques, as well as symptomatic evidence, as it is done in clinical analysis (Lachance *et al.*, 2001; Petersson and Jacobsson, 2002).

Contrary to clinical analysis, in bioarchaeology, the hallmarks of OA are based solely on bony alteration of the synovial articular surfaces. The bony changes observable include new bone formation on the synovial joint margins, as well as on the articular surface, known as osteophytes; pitting (porosity) of the surface of the joint; and eburnation. This latter is for some researchers the final state of the disease. It is represented by polished areas of the articular surface (rarely the entire surface) due to direct contact between the bones. Colloquially, one may say that eburnation results from "bone on bone" attrition after loss of cartilage (Aufderheide and Rodríguez-Martín, 1998; Roberts and Manchester, 2005; Rogers and Waldron, 1995; Rogers *et al.*, 1987). Based on these bony changes several diagnostic criteria schemes were developed, and have since been used consistently in the

[16] These new technologies have also raised novel questions. Applying the new technology is not enough; one still needs to know how to identify the lesions which are pathological from the ones that are not. Therefore, the comprehension of the output provided by the new imaging techniques has become a necessity as bone/joint morphology analysis, otherwise normal individual morphological variations, which may mimic disease lesions, may be misinterpreted (Yoshioka *et al.*, 2004).

bioarchaeological diagnosis of OA. The most often used method was introduced by Juliet Rogers and colleagues (1987):

> Osteoarthritis is characterized in skeletal material by (1) the formation of true, marginal osteophytes; (2) subchondral bone reaction (eburnation, sclerosis and cysts); (3) pitting of joint surfaces; and in severe cases (4) alterations in the joint contours. In the absence of (1) and (2), joint changes cannot be classified as being osteoarthritic, but the presence of osteophytes alone may be the result of a simple age change. Osteoarthritic changes can affect any of the synovial joints of the body but are most noticeable in skeletal material in the large joints (hip, knee) and in the facet joints of the spine (Rogers *et al.*, 1987: 185).

A later, and more conservative approach to OA uses solely the presence of eburnation as being indicative of OA. This is so because eburnation is considered the only true pathognomonic sign of the condition (Inoue *et al.*, 2001; Perlman *et al.*, 1992; Rogers and Waldron, 1995; Waldron, 1993, 1997b). In the absence of eburnation, and as referred above (ibid), bony changes should only be used in combination (Rogers and Waldron, 1995; Waldron, 1995). Other methods were developed to assess OA, and although the same bony changes are taken into consideration, their evaluation within the context of OA appraisal is diverse. For instance, Charles Merb (1983) considered that the presence of any of the bony changes (osteophytes, porosity and eburnation) was sufficient to diagnose OA, as each bone change was examined and scored separately; Robert Jurmain used a classification system based on the degree of severity of degenerative involvement, which included lipping (osteophytes), porosity, and eburnation (Jurmain, 1975, 1980). Further recording protocols of degenerative joint lesions were systematized, all based on the same degenerative bony changes in the articular surfaces, but their approach to the changes diverges (Buikstra and Ubelaker, 1994). In Table 1 are some of the criteria used to assess OA in bioarchaeological contexts. The purpose of this table is to exemplify the different approaches OA diagnostic criteria within bioarchaeological contexts.

Table 1 – Example of OA assessment on bioarchaeological studies (ordered by year of publication).

Criteria OA diagnosis	Authors
Ordinal values computed into single value per joint (for detailed description see reference to Jurmain, 1975)	(Jurmain, 1975) (Jurmain, 1980)
Eburnation or two of the following: marginal osteophytes, new bone of the joint surface, pitting or deformation of joint contour (described Rogers *et al.*, 1987)	(Waldron and Rogers, 1991)
Combining values of all articular surfaces, based on Merbs (1993) recording method	(Bridges, 1991)
Eburnation or two of the following: marginal osteophytes, new bone of the joint surface, pitting or deformation of joint contour	(Waldron, 1992)
Solely based on the presence of eburnation	(Waldron, 1993)
Eburnation or two of the following: marginal osteophytes, new bone of the joint surface, pitting or deformation of joint contour	(Waldron, 1995)
Eburnation or two of the following: marginal osteophytes, new bone of the joint surface, pitting or deformation of joint contour	(Waldron, 1997b)
Solely based on the presence of eburnation	(Inoue *et al.*, 2001)
Averaging of z-scores for OA scores taken according to the Buisktra and Ubelaker (1994) recording protocol	(Weiss, 2005)
Combination of several degenerative bone changes: osteophytes, lipping and eburnation	(Cope *et al.*, 2005)
Combination of modifications: periarticular bone formation (with exception of "barely discernible"(Buikstra and Ubelaker, 1994)); subchondral bone resorption; eburnation .	(Lieverse *et al.*, 2007)

The overall lack of information concerning the analytic procedure to undertake, particularly with regard to statistics, is another source of variation is bioarchaeological studies. Although recording protocols extensively describe what to record, they lack systematization with regard to the manner in which information should be extracted from the data. The more immediate result of this lack of systematization is the proliferation of variability in the outcome results of many studies. Some authors code the bony lesions as categorical data, refering only to its present or absence; others employed ordinal scales, in which gradients of the bony changes are considered (Buikstra and Ubelaker, 1994; Weiss, 2006). Furthermore, some investigators focus on single articular surfaces, whilst others deal with "entire joints" (shoulder, elbow, knee, hip). Additionally, even that which is defined as a as complex joint may vary between authors: some may use all compartments of the joint, and others may consider only part of it. Moreover, some studies may even fail to mentioned the exact method used, with the exception of occasional reference to lipping (Papathanasiou, 2005: 384).

The lack of systematic scoring systems is still one of the major limitations of OA bioarchaeological research. If these are allied with other inherent problems of bioarchaeological studies, such as limitation in sexing, ageing adult skeletons, and insufficient correlation with clinical data, one wonders about the overall viability of bioarchaeological approach to pathologies (Bridges, 1993a; Jurmain, 1999; Jurmain and Kilgore, 1995; Waldron and Rogers, 1991; Weiss and Jurmain, 2007). One of the major consequences of this situation is the inability of population comparison, as studies employ different recording methods and different analytic procedures. This ultimately reinforces the idea that bioarchaeologists, although capable of easily recognizing the bony changes, lack consensus in the systematization of the data observed, leaving bioarchaeological approaches to OA much to the interpretation of the researcher. Consequently, differences in the prevalence of a disease between similar populations do not necessarily reflect population-specific patterns of bony changes, or in the case discussed above, OA. They may instead reflect the diversity of criteria used in the assessment of the pathology. In the end, instead of addressing OA prevalence through history, one may in fact be accounting for the "evolutionary history" of a bioarchaeological approach to OA.

Further to the lack of systematic scoring systems, the importance given to the different bony changes in the assessment of OA is also cause for concern. For instance, why should bioarchaeologists overlook osteophytes over eburnation? Whilst eburnation is regarded as pathognomonic of OA, osteophytes are not. In fact, and in accordance to what was argued by Rogers and Waldron (1995) "In practice little will be lost by restricting the diagnosis to include only those joints with eburnation" (p. 44). Since their criterion is consistently used and referred to in bioarchaeology, researchers limit themselves to follow the instructions. Many may not agree with the affirmation that little will be lost when only eburnation is considered (Bridges, 1996), but the practice has proven popular, as there is still research done in bioarchaeological samples that focus solely in eburnation. The exclusion of osteophytes is even more worrying as these bony changes are one of the major criteria used in the clinical diagnosis of OA (Altman *et al.*, 1991; Altman *et al.*, 1990; Altman *et al.*, 1986; Altman and Gold, 2007; Kellgren and Lawrence, 1957a, 1957b). Moreover, it was also proven that grade 1 osteophytes (according to Kellgren and Lawrence grading system) can evolve into "true osteophytic knee OA" (Hart and Spector, 2003: 149). It is worthy of note that the use of "trace" osteophytes in clinical diagnosis is also contradictory. In a clinical context, and on their own, they are regarded as merely age-related, and not directly associated with OA. This was argued in cases when osteophytes appear in the absence of other bony changes, i.e., subchondral cysts or subchondral sclerosis (Altman and Gold, 2007; Brandt, 1999; Sandell and Aigner, 2001; Spector *et al.*, 1993; Van der Kraan and Van der Berg, 2006; Yamada *et al.*, 2002). This later perspective fits the overall approach to OA undertaken by many bioarchaeologists.

The major reason appointed to overlook osteophytes on OA analysis is the strong association found with age. However, in bioarchaeological contexts, osteophytes and particularly marginal osteophytes are one of the commonest forms of bony change. For this reason perhaps one should embrace alternative approaches to degenerative bony changes in the joint in bioarchaeological contexts. Instead on trying to quantify OA prevalence, one might give more importance to the quantification of degenerative bony changes (DBC) *per se*. Ultimately, one should try to determine the real correlation between DBC within clinical and archaeological contexts, and not simply assume that OA is the must common disease observed in archaeological samples. One should also remember that clinical and bioarchaeological studies do not have the same objectives, therefore comparisons between results may not be as informative as expected.

Despite the strong age-related issues surrounding osteophytes in OA diagnosis, its formation is an integral component of OA pathogenesis (Gilbertson, 1975; Van der Kraan and Van der Berg, 2006). Apart from being understood as age-related, the occurrence of osteophytes can also represent an adaptive response of the joints, to promote stability (Poole, 1999; Van den Berg, 1999). It can also be regarded as a mechanism of cartilage repair rather than one of degradation (Neuman *et al.*, 2003; Sandell and Adler, 1999). This latter approach empowers its use in the assessment of differential mechanical load between individuals, or individual joints. Age may play a role in their development, but one should not disregard their importance in the overall aspect of OA development: "Marginal osteophytes are most sensitive radiographic features for detection of articular cartilage degeneration (within patellofemoral joint). Other features such as joint space narrowing, subchondral sclerosis and subchondral cysts rarely occurred without osteophytic formation, making those a key feature in the diagnose of OA in patellofemoral joint" (Kijowski *et al.*, 2006).

The overall discussion about OA and the methodological criteria of diagnosis has demonstrated that nothing in the osteological approach to OA is as simple and straightforward as originally thought. The multitude of factors involved in the pathogenesis of the disease, exemplified by the ever growing amount of research done on age, genetics and joint morphology, stands testament to this predicament (Weiss and Jurmain, 2007). Although age continues to be one of the major risk factors of OA, itself described as a disease of middle age to late adulthood, the risk of its development is also associated with other systemic factors (metabolic, hormonal, genetic, and sex-related), local biomechanical factors (such as mechanical workload), body mass index, joint morphology,[17] and other pathologies (Aspden *et al.*, 2001; Bulllough, 2004; Christensen *et al.*, 2005; Doherty, 2001; Gillespie and Porteous, 2007; Golightly *et al.*, 2007; Lachance *et al.*, 2001; Mustafa *et al.*, 2000; Reijman *et al.*, 2007; Sharma *et al.*, 2001; Wluka *et al.*, 2005). For instance, the presence of OA in women's hip was found to posses a strong genetic foundation (Lanyon *et al.*, 2000; MacGregor *et al.*, 2000; Mustafa *et al.*, 2000; Spector *et al.*, 1996; Williams and Jimenez, 2003); advancement in age, and a greater body mass index tend to favour the presence and size of osteophytes in osteoarthritic knees (Ozdemir *et al.*, 2006; Reijman *et al.*, 2007); a high body mass index and intense physical activity increases the risk of development of primary OA on the hip (Flugsrud *et al.*, 2002); and acetabular dysphasia has also being referred to as a predictor of hip OA (Reijman *et al.*, 2002). Hence, whatever approach is pursued in

[17] The characterization of synovial joints, also known as diarthroses is complex, expressing not only the type of movements they perform, but also the joint's anatomic morphology. With regard to their "mobility" joints can be uniaxial (movement around one axis), biaxial or mutiaxial (movements around two axes or more). Morphologically they can be described as hinge, condylar, ellipsoid, saddle, pivot, ball and socket or plane, each one bearing its own peculiarities (Adams, 1993; Gunn, 2002). Each shape has its own stability properties, which may partially explain the minor or major affection of OA in a particular joint (Simkin, 1993). For instance, the ball and socket morphology of the hip joint allows for a wide motion, whilst ensuring complete joint stability, hence its ability to accommodate a wide range of mechanical constraints (Simkin, 1993).

bioarchaeological research of OA it should consider all of the above, or at least as many variables as possible.

It is not only OA aetiology that may be diverse. The bony reactions used to classify and/or diagnose OA have also proved to be of motile-aetiology. For example osteophytes present a high degree of variation according to morphology, local alignment, and bone response to mechanical constraints according to joint surface (Huch, 2001; Kindynis *et al.*, 1990; Nagaosa *et al.*, 2002; Ozdemir *et al.*, 2006; Shepstone *et al.*, 2000). Eburnation was found to be related to joint morphology, reinforcing the importance of anatomical considerations in the interpretation and analysis of eburnation (Shepstone *et al.*, 2001). The only ever growing certainty is that there are no *absolute truths* in OA diagnosis, either in clinical or bioarchaeological contexts.

Considering all that has been said about OA aetiology, diagnosis and assessment, one must necessarily question how much of OA is explained by behaviour? The assumption used in bioarchaeological analyses is that a joint affected with OA corresponds to a joint which was subjected to an overall high, and repetitive level of stress. This hypothesis disregards all other facts enumerated in the previous pages. The statement translates an oversimplified version of reality, which may even be incorrect. Ironically (depending on ones point of view), and based on clinical data, the straightforward assumption that "a disused joint never develops osteoarthritis, but a misused one often does" (Merbs, 1983: 19) was found not to be as clear-cut as frequently thought (Shrier, 2004). Particular patterns of degeneration may be caused due to lack of use. In these cases unused joints show a similar behaviour to the one found in atrophied organs, as an expression of the interdependency of the anatomy (e.g., morphology, ligaments, and materials) and function (e.g., motion, load distribution, and stability) of a joint (Bullough, 2004; Herzog *et al.*, 2003; Sokoloff, 1969). The premise being that an unused joint is lesser prepared to dealt with mechanical stress, being therefore more susceptible to develop degenerative changes (Bulllough, 2004; Plochocki, 2004; Slemenda *et al.*, 1998). Furthermore, it as also been demonstrated that low to moderate physical activity does not necessarily increase the risk of OA. In joints such as knees or hips it has been observed that low to moderate levels of physical activity could in certain cases reduce the risk of OA

(Hootman *et al.*, 2003; Lane *et al.*, 1993; Rogers *et al.*, 2002; Sutton *et al.*, 2001; Sylvester *et al.*, 2006; Thelin *et al.*, 2006).

There are of course clinical and epidemiological studies that have established a liaison between certain sports, and the risk of OA. These findings fit the overall agenda of bioarchaeological interpretation of OA. These studies included sports that demanded high-intensity, acute, direct joint impact thought contact with other participants, playing surfaces, or equipment (Buckwalter and Lane, 1997; Drawer and Fuller, 2001; Felson *et al.*, 2000; Kujala *et al.*, 1995; Lane *et al.*, 1993; Lequesne, 2004; Thelin *et al.*, 2006). There are also studies that report a relationship between specific occupations and the onset of OA. That was the case of the study developed by Coggon and colleagues (2000). The authors reported that subjects performing specific activities such as kneeling and squatting, as well as occupations requiring lifting, presented higher OA risk. This risk increased significantly when associated with obesity (Coggon *et al.*, 2000). M. Rossignol and colleagues found the greatest prevalence rates of OA in females who were cleaners, women working in the clothing industry, male masons and other construction workers, and agricultural male and female workers. The heavier the level of labour undertaken, the earlier the onset of OA, with the first symptoms appearing before the age of 50 (Rossignol, 2004; Rossignol *et al.*, 2005; Rossignol *et al.*, 2003).Consistently, other studies have also demonstrated a liaison between OA and repetitive mechanical behaviours, such as kneeling, squatting and climbing found in farming, coal mining and shipyard working (Holmberg *et al.*, 2004; McAlindon *et al.*, 1999; Petersson and Jacobsson, 2002). OA has also been revealed to be a product of fashion, as proven by Kerrigan and colleagues (2001, 2005). They assessed whether wearing wide-heeled or moderately-heeded shoes had a similar effect on knee torque, than narrow-heeled shoes. Their findings implied that wide-heeled shoes had a high impact on the patellofemoral and medial compartments of the knee, typical anatomical sites for degenerative joint changes (Kerrigan *et al.*, 2005; Kerrigan *et al.*, 2001).

Osteoarthritis complex aetiopathogenesis with genetic, metabolic, infectious, normal ageing and mechanical stress factors contributing to its development, has proven that its presence is not just consequence of "wear and tear" of the joint tissues throughout the life of a person. Hence caution must be applied when interpreting any results concerning OA at an individual or populational level. As demonstrated by many of the clinical studies mentioned above, most of the time there is not only one factor influencing the onset of the disease but several, may it be sex, age, excess weight or previous injuries (Conaghan, 2002; Kujala *et al.*, 1995; Sutton *et al.*, 2001; Thelin *et al.*, 2006). The preconceived idea that a more mechanically demanding lifestyle would increase the prevalence of degenerative articular lesions needs to be readdressed. In fact the number of variables that may influence the prevalence of OA is immense, and can be as trivial as working in a farm with or without animals, as proven by the study developed by Thelin and collegues (2004);[18] or to be subjected to mechanical vibration (Radin, 1993).[19] Simple questions as to the durability/exposure to a particularly physically demanding lifestyle may also play a role in the prevalence of the disease (Kellgren *et al.*, 1953; Maquirriain *et al.*, 2006; Solomon *et al.*, 1976).

The insufficient correlation with clinical data, already mentioned, is another major problem in the analysis of OA in human skeletal remains. One necessarily needs to question whether bioarchaeologists are quantifying OA in human skeletal remains, or if the clinical syndrome of osteoarthritis is too far away from the osteological evidence? Is it really a case of clinical syndrome *versus* osteological evidence (Buckwalter and Lane, 1997)? Based on the fact that the osteological specific degenerative changes are easily identifiable, OA is believed to be extremely common in human skeletal remains (Ortner and Putschar, 1985). However, based on the evidence, such as the multitude of criteria and methods used to determine the presence of OA in archaeological remains, are bioarchaeologist really looking at what can be called OA? Should bioarchaeologists simply name the articular bony lesions observed in diarthroses as what they are: osteophytes, porosity and eburnation i.e. degenerative bony changes (DBC), instead of randomly describing and quantifying these changes as OA? After all, if OA "is not one disease, but many

[18] The presence of animal production showed a significant positive relationship with the risk of developing hip joint osteoarthritis (Thelin *et al.*, 2004).

[19] OA is not necessarily related with an harmful overall load of the joint, but with vibrating and repetitiveness of the load, which as a cumulative and deleterious effect on the joint surface and its capability to regenerate (Radin, 1993).

diseases that end up with a common structural lesion" (Sokoloff, 1969:115) what are we determining?

In summary, the lack of clinical correlation, problems of standardisation of scoring bony changes, as well as statistical analysis (briefly mentioned above) plus missing ethno-historical documentation on past archaeological populations, and oversimplified behavioural inferences, summarise the major limitations to the bioarchaeological approach of OA (Jurmain, 1999; Jurmain and Kilgore, 1995). Clinical studies on the evaluation of ethnical differences with regard to the present of OA, have shown that differences in ethnicity may not necessarily be related to biology, but depend on lifestyle, and socioeconomic factors (Anderson and Felson, 1988; Felson *et al.*, 2000; Jordan *et al.*, 1995; Sowers *et al.*, 2000). Sociocultural differences may also be an important factor to consider in the diagnosis of clinical OA, as the definition of pain may be vague and uneasy to quantify, as a culturally-dependent definition (Lachance *et al.*, 2001; Link *et al.*, 2003). As a result, OA should never be assessed on one single type of dataset (Reijman *et al.*, 2005). Unfortunately, bioarchaeological analysis is limited with regard to data availability. Furthermore, problems of age determination in adult skeletal remains, in the analysis of a pathology that is highly age-related, represents a powerful bias in any analysis performed. The interpretation of degenerative bony changes caused by skeleton biological senescence, as opposed to changes due to pathological or biomechanical conditions, such as activity, represents another big challenge in the use of OA as a MOS. Hence the need for caution whilst inferring behaviour based on OA.

3.2.1.2 Muscle Stress Markers (MSM): An overview

Many of the considerations discussed for OA are also applicable to MSM, therefore the overall assessment of this MOS will be more succinct. In the present research the designation of *musculoskeletal stress markers* (MSM), will be used as synonym of enthesopathies. It will address changes observed in the entheses,[20] which are the point of attachment of muscle, tendons, and ligaments to bones or joint capsules (Freemont, 2002; Freivalds, 2004). Musculoskeletal stress markers are seen as intimately related with activity in bioarchaeological contexts. They are used to assess activity, based on the assumption that an individual engaged in a high or higher mechanical stress constraints, will posses higher degrees of changes when compared to his counterparts. Detailed reference to bioarchaeological MSM has already been widely discussed by Jurmain, Larsen and many others (al-Oumaoui *et al.*, 2004; Eshed *et al.*, 2004; Henderson, n.d.; Mariotti *et al.*, 2004; Molnar, 2006; Villotte, 2006; Weiss, 2004).

Beyond the scope of bioarchaeology, MSM are the result of an healing process, resulting from "the formation of new, woven osteoid from either fibrous tissue or by endochondral ossification" (Freemont, 2002: 3), which remodels and is replaced with lamellar bone. They represent irregular outgrowths that extend from the bone into the tendon or ligament (Benjamin *et al.*, 2000; Rogers *et al.*, 1997), being particularly characteristic of the iliac crest, patella, calcaneus and spine (Ruhoy *et al.*, 1998). For some, MSM would be for the entheses what osteophytes are for the joints: an attempt towards stability (Shrier, 2004).

MSM are commonly identifiable as inflammatory, and non-inflammatory reactions (Freemont, 2002). On the one hand non-inflammatory enthesopathies can be described as traumatic, degenerative and metabolic. The first category includes single episodes of extreme loading, such as sports injuries. The second results from tissue damage due to chronic, repetitive and relatively painless charges, also associated with age, and sometimes asymptomatic despite its radiological identification. Thirdly, metabolic enthesopathies may be consequence of the disruption of the deposition of crystals, such as calcium pyrophosphate and hydroxyapatite in the ligament or tendon (Benjamin *et al.*, 2002; Claudepierre and Voisin, 2005; Freemont, 2002). Clinically, a traumatic enthesopathy may mimic a bone tumor, such as a chondrosarcoma or osteosarcoma, and only biopsies can rule

[20] Enthesis, singular of entheses, "is a word derived from Greek to designate the structures that attach ligaments, tendons and joint capsules to bone" (Claudepierre and Voisin, 2005: 32): ligament connects bone to bone, and provides stability to the joints; tendons connect muscle to bone, transmitting the muscle force; cartilage covers articular bone surfaces and is also found in ear, nose and in intervertebral discs (Freivalds, 2004).

out this diagnosis (Freemont, 2002). In this sense, the identification of enthesopathies is easier to obtain in bioarchaeological contexts, than in clinical ones. Finally, inflammatory enthesopathies are common components of the syndromes of rheumatoid disease as well as seronegative spondylarthropathies (Freemont, 2002; Resnick and Niwayama, 1983).

The current consensus is that most MSM lesions are the result of overused injuries at the entheses (Benjamin *et al.*, 2002; Shaw and Benjamin, 2007). Some authors have argued that one should also pay attention to lesions caused by "underuse". Maganaris and colleagues (2004) have suggested that some entheses sites are unprepared to adapt to high or increasing load, hence more prone to damage. These "underused injuries" would occur in stress-shielded areas (Naganaris *et al.*, 2004; Shaw and Benjamin, 2007). This has been an approach overlooked by bioarchaeologists, for whom entheses with MSM were equivalent of areas subjected to higher demanding loads. Entheses have heterogeneous architecture, not only between them (discussed below), but also within a particular site, each one with singular properties and capabilities to adapt and deal with tensile and /or compressive stress forces (Shaw and Benjamin, 2007; Toumi *et al.*, 2006). Toumi and colleagues (2006), in an analysis of patellar tendinopathy, discovered that it particularly affected the posteriomedial part of the patellar tendon. This tendon is often overused in sports and can lead to injury. It has been frequently associated with athletic jumping, elite volleyball and basketball players. The correlation found between the patellar tendinopathy and the patellar posteriomedial part proved to be indicative of the fact that the functional anatomy of the knee is closely related to regional variations. Therefore, the mechanical stress at the proximal patellar tendon was asymmetrically distributed, being greater in the medial side (Toumi *et al.*, 2006).

A brief review on the nature and structure of entheses revealed one of the major problems of MSM bioarchaeological analysis. Bioarchaeological analysis of entheses has disregarded the entheses heterogeneity. There are at least two entheses types observable in the human skeletal remains: fibrous (Fe) and fibrocartilaginous (FCe) entheses. Fe corresponds to the metaphyseal of diaphyseal bone attachment site, whilst the latter ones are found on the chondro-apophyseal attachments. Their different designation relates to the overall tissue architecture of the tendon-bone interface. This differential architectural type provide specific properties to the entheses type, determining their ability to respond to stimuli (Benjamin *et al.*, 1986; Benjamin *et al.*, 2002; Benjamin *et al.*, 2006; Claudepierre and Voisin, 2005; Shaw and Benjamin, 2007). Adult tendons FCe are typically divided into four-layered histological identifiable zones: tendon or the ligament itself, uncalcified fibrocartilage, calcified fibrocartilage and bone (Benjamin *et al.*, 2002; Benjamin and McGonagle, 2001: 3; Benjamin and Ralphs, 1996; Resnick and Niwayama, 1983). This permits the entheses to dissipate stress and ensure that the fibres, near the bone, bend gradually, preventing damage (Benjamin and Ralphs, 1996; Benjamin *et al.*, 1991; Morriggl *et al.*, 2001). They have been more attentively studied by clinicians, as they are regarded to be more vulnerable to overuse injuries. Fe can attach to the bone directly, particularly in adult individuals, or indirectly as observed in childhood. In this later case the tendon attaches to the bone *via* the periosteum. These ones can with time attach directly into the bone, a consequence of the bone growth and adaptation of the tendon to the site (Benjamin *et al.*, 2002; Benjamin and Ralphs, 1996; Shaw and Benjamin, 2007).

The osteological appearance of entheses is that of ridges, tubercles and tuberosities which are effortlessly identifiable in bones. Metaphyseal and epiphyseal sites are easily recognizable. These are associated with raised bridges, or rough surfaces of the bone (Benjamin *et al.*, 1986; Benjamin *et al.*, 2002; Hems and Tillman, 2000). It is precisely the changes in these sites that are used by bioarchaeologists to infer overuse and injury in the tendon-bone interface. These changes are ultimately employed to deduce behaviour, or activity-patterns which were mechanically demanding on the musculoskeletal system, and inevitably left their mark on the skeleton. The bone exterior of Fe and FCe attachment is different in appearance. In FCe the site of attachment appears as smooth, circumscribed and without vascular foramina. In *periosteal* Fe, that is, Fe that attach *via* periosteum to the entheses, there are some rough markings present, more extense than the ones observable in FCe, and the entheses area is less circumscribed making it difficult to establish boundary lines (Benjamin *et al.*, 1986; Benjamin *et al.*, 2002).

Boundary limits of the entheses are another aspect to consider, whilst analysing enthesopathic lesions. For instance, the tendon ligament attached to bone may "flare out" in order to increase the surface area of the attachment, such is the case of the attachment of the Achilles tendon to the calcaneus, and of the *pes anserinus.* This latter is the location of the insertion of the conjoined tendons of three muscles onto the antero-medial proximal tibia (Figure 2).

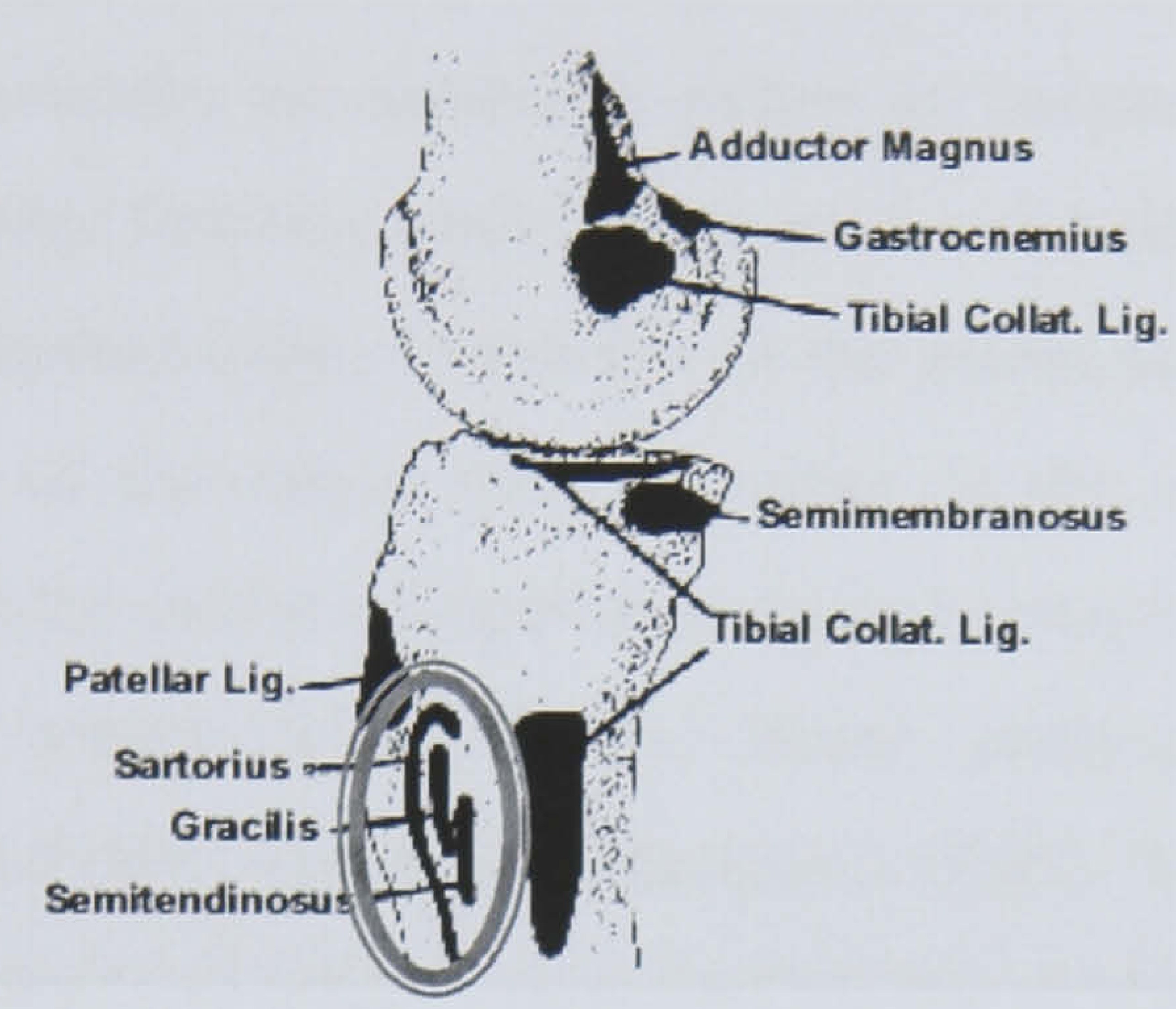

Figure 2 – Example of the complex neighbouring insertion site of muscles onto the proximal extremity of tibia. The figure refers specifically to the *pes anserinus.*

(*In:* Anatomy and Kinematics of the Normal Knee. Kenneth A. Krackow, M.D., and David S. Hungerford, M.D., http://aboutjoints.com)

The importance of this illustration is to show that neighbouring tendons interconnect, and that dry bone boundaries are not as circumscribed as thought. Such interconnectivity acts as a better support, as well as stabilizer, for mechanical loads (Shaw and Benjamin, 2007: 2). Most importantly it revealed that, in dry bones, an area is not exclusive of a single bone-tendon/ligament insertion. It also illustrates that the structure of entheses varies significantly between regions, and that FCe may also vary within, that is, a FCe may not be fibrocartilaginous in all areas (Benjamin *et al.*, 2002; Hems and Tillman, 2000; Shaw and Benjamin, 2007). This issue exemplifies that when accounting for MSM in an entheses, maybe one should not refer to a single muscle-tendon-ligament system. Entheses do not only represent themselves, but also the adjacent structures that help to cushion stress concentration at the attachment sites. This complex has been described as "enthesis organ" (Benjamin and McGonagle, 2001; Benjamin *et al.*, 2006; Shaw and Benjamin, 2007; Slobodin *et al.*, 2007): "enthesis organ are a collection of related tissues at and near the enthesis, which serve a common function of stress dissipation" (Benjamin *et al.*, 2006: 474). Some enthesis organs have a very complex structure, and represent multi-enthesis organs: "where two or more neighbouring tendons or ligaments share an enthesis" (Benjamin *et al.*, 2006: 474). This situation explains why symptoms associated with a particular enthesopathy are diffused, such as in patients with epicondylosis (tennis elbow). The pain radiates into the neighbouring ligaments, specifically if they act as a "multi-enthesis organ" (Benjamin *et al.*, 2006).

Contrary to what happens with the diagnosis of OA, the identification of MSM in skeletal material is considered to be relatively easy. Changes in the entheses can effortlessly be observed, either as outgrowths from the periosteal surface, or as pitting. This has made the diagnosis of MSM a relatively straightforward exercise in bioarchaeology, so much that the production on articles based on MSM analysis is one of the major research topics in this discipline. These articles mostly address activity and/or occupational-related changes. However there are several publications in which MSM have been analysed in the context of seronegative spondylarthropathies (Marques, 2007: bioarchaeological and clinical review). Similarly to what is done in OA, the majority of studies focus on the assessment of differences between populations, specifically prehistoric populations (hunter-gatherers *versus* agriculturalist). The research aims to identity patterns of workload activities, based on the assumption that changes in the subsistence activities influenced the overall musculature of the individuals (Churchill and Morris, 1998). Research on sexual division of labour and social status are other topics that use MSM as their major comparative, or hypotheses testing variable (Groves, 2006; Papathanasiou, 2005; Peterson, 2000, 2002 ; Robb *et al.*, 2001; Sullivan, 2004).

Curiously the application of MSM to occupation, or activity-related changes, has never been seriously questioned until recently. There are references to the inadequacy of the methodologies used in MSM assessment, as well as to the fact that most studies disregard other confounding variables that may influence MSM outcome. This, and many other issues concerning the analysis of MSM were already compiled in a volume of *International Journal of Osteoarchaeology*, in 1998 (previously mentioned), and recommendations for future research were made. The chronological period addressed by the collection of papers ranged from the terminal Pleistocene (12,500 – 10,000BC) until the modern epoch. Geographically the papers analysed material recovered from Palestine and Jordan, to South Africa and New Mexico (Churchill and Morris, 1998; Hawkey, 1998; Peterson, 1998; Peterson and Hawkey, 1998; Robb, 1998; Steen and Lane, 1998; Stirland, 1998; Wilczak, 1998). Although some papers had a more conventional approach to MSM, emphasising activity-related issues (Hawkey, 1998; Peterson, 1998), the majority of the papers adopted a rather simplistic critical posture by focussing on the way in which MSM were used to assess occupation and/or activity-related lesions in the human skeleton. Some authors questioned the importance of sex, age, handedness and genetics in the development of entheses, and entheses lesions. Others questioned whether stress markers and robusticity were indeed a measure of labour intensity, referring to the importance of biotic differences between regions, environment, and a long-life activity history and diet as an important factor in individuals' reaction, and differentiation in muscle marking. Furthermore, questions were raised regarding the fact that muscles function as a group, and not singularly, hence the need to consider muscle groups when attempting to reconstruct patterns of activities. Additionally, an effort was made to express the fact that entheses are complex systems, and that a sole site may convey more than a particular activity-effort, and that enthesopathies are a mosaic of the activities undertaken (Churchill and Morris, 1998; Robb, 1998; Stirland, 1998; Wilczak, 1998). The overall approach to MSM, in the majority of the articles in this volume, was an awareness of the necessity to address basic questions concerning the assessment of MSM and their viability as activity-related markers. Despite this attempt, many of the issues raised in the volume are still being discussed today, such as the importance of determining the effect of confounder variables such as age, sex and enthesis morphology. On the other hand the subjectivity of the methods used, and their universally indiscriminate application to entheses, that are known to be structurally and functionally divergent, are also themes on the agenda (Henderson, n.d.; Henderson and Gallant, 2005, 2007; Villotte, 2006). Almost ten years have passed since that volume of *International Journal of Osteoarchaeology*, and still the dilemmas linger. Kennedy's acclaim for highlighting the need for a shift in the bioarchaeology approach to MOS is indeed still echoed in recent publications:

> Rather than continuing the venerable practice of first deciding that a bone modification is a marker of occupational stress, it is recommended that we initiate investigations with a sharper perception of how bone remodelling takes place and which kinds of modifications bone may assume within the configurations of habitual activity revealed in archaeological and historical sources. To do so will deliver us from the blunder of *Currus bovem trahit praepostere* "To put the cart before the ox."(Kennedy, 1998: 309)

The urgency expressed by Kennedy is still a demand today, and although new voices have joined the critical calls and appeals for change, there is still a lot to be done. There is an urgent need for bioarchaeological studies to be independent yet complementary to the fields of medical, clinical, epidemiological and technological research (Henderson, n.d.; Jurmain, 1999; Pearson and Buikstra, 2006).

One of the major problems in establishing a reliable method to assess MSM in skeletal remains is a simplistic view of entheses, which reflects the overall lack of comprehension of the anatomical complexity of the site and structure under analyses. This is one of the major critiques applied to the current assessment of MSM in bioarchaeology. The majority of studies publish after 1988 rely mostly on the method developed by Diane Hawkey, later expressed by Hawkey and Charles Merbs (1995), despite the existence of alternative methods (Crubezy, 1988; Dutour, 1986; Mariotti *et al.*, 2004). In general terms, although all of these methods acknowledged MSM variable expression, either bony growths or pitting, they do not distinguish between entheses (Fe *versus* FCe). Until recently, only the methods proposed by Sebåstian Villote (2006), have considered entheses heterogeneity in the assessment of MSM in a bioarchaeological context.

Another problem in bioarchaeological assessment of MSM, is the wide range of criteria used. The recording methods vary from the basic *Presence/Absence* of lesions (Dutour, 1986), to the categorization of the lesions according to the *lesser* or *major* expression of the lesion (Crubezy, 1988; Hawkey, 1988; Hawkey and Merbs, 1995; Mariotti *et al.*, 2004; Robb, 1998; Stirland, 1998; Wilczak, 1998). Advantages and disadvantages have been associated with those methods. On the one hand these methods are non-destructive, they do not require major equipment, they are easy to reproduce and accessible to any researcher. Additionally inter and intra-observer errors have been reported as low (for details see Hawkey and Merbs, 1995: 327). On the other hand, some authors have referred to the fact that the methods deal with categorical data, which do not convey numerical values, nor fully express the degree of *lesser* or *major* expression of an enthesopathies. Neither does it convey that the data may be populational-related, varying according to each sample, as well as according to the inherent robustness or gracility of the bone (Robb, 1994; Wilczak, 1998). However, alternative methods have considered the measurement of the insertion site areas, as well as of the height and length (Churchill and Morris, 1998; Henderson and Gallant, 2005, 2007; Wilczak, 1998). This particular issue reinforces the need for consideration of individual variability, and ability of bony production, as a major variable in the study of MSM, and of other MOS (Rogers *et al.*, 1997). Many studies also disregard the potential influence of other factors such as age, sex, genetics and, the respective responsiveness of the entheses to load, according to each one of those parameters (Stirland, 1998; Wilczak, 1998). Discussions concerning the differential response to the several entheses to a particular type of activity (i.e. endurance *versus* short intensive activity), to the overall maturation of the skeleton when subjected to a particular type of activity, as well as its durability (i.e. long-life result or a short-time before death event), are all issues underlined by Stirland (1998) and Wilczak (1998). Many researchers are now strongly advocating a better understanding of entheses, and entheses-activity relationship before advancing with inferences regarding behaviour in past and present populations (Zumwalt, 2006).

Charlotte Henderson (2003-2007) has focussed her research on MSM recording over the last few years[21]. The author has grasped the necessity to consider the soft tissues properties of the entheses (Henderson, n.d.). Her approach to MSM has also been adopted by Sebástian Villote (2006) who has already published a new method which addresses entheses according to their typology. As advocated by Henderson, a new recording method should be developed for both fibrous as well as fibrocartilaginous entheses, but even then one would need to address issues of "normality" appearance of the entheses. As argued by Henderson: "In the case of fibrocartilaginous entheses any deviation from complete smoothness could be considered an enthesopathy. Smoothness still needs a definition, because even macroscopically smooth surfaces have microscopic roughness. [Furthermore] once smoothness has a definition, roughness still needs to be related to its cause."[22]

Ann Stirland concludes that "attempts to evaluate areas of muscle insertion either by measurements or by subjective evaluation are doomed to failure" (Stirland, 1998: 360). Insertion areas are hard to define, particularly in slightly damaged or modified skeletal material, that the repeatability of the measurements would be difficult, and a

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[21] Most of the author's contribution has been in conferences participations (Henderson, 2003, 2004, 2005, 2006, 2007; Henderson and Gallant, 2005).
[22] Charlotte Henderson communicated privately.

subjective evaluation, as the term implies, would be liable to high variation. Furthermore, most of the studies presented tend to consider muscle insertion sites as separate identities, when in reality muscle and joint act together (Robb, 1998; Stirland, 1998). It is therefore simplistic, to associate any single muscle with any particular activity, nor should research try to map the patterns of limb involvement in a particular activity by devoting attention exclusively to a bone, enthesis or joint.

In bioarchaeological terms, the discussion of MSM results is as follows: the bigger the changes, the higher the value of stress endured by the subjects. There are rare references to the intensity, and durability of the mechanical load. Also, the overall pattern of higher or lesser MSM degrees in different entheses of a same individual may reflect the variety of entheses structures and the way each one reacts to the same stress or different stress and *not* merely a reaction to stress load itself (Zumwalt, 2006). Furthermore, if entheses were "designed" to cope with several stimuli, they are capable of buffering external stimuli, at least to a certain degree. In fact, fibrocartilaginous entheses have a four layer architecture that buffers the external loads, permitting a gradual transition between the stress/stimuli and bone; other entheses attach over very broad areas of bones, hence dissipating the stimuli, reducing the stress impact over the large area (Zumwalt, 2006). If that is the case, why are bioarchaeologists so keen to attribute entheses changes to activity? And does activity really manifest itself so easily in entheses? Ann Zumwalt (2006) found contradictory results within this latter assumption. The author found that endurance exercise had no effect on the morphology of the muscle attachment site tested. This finding on the one hand challenged the long-held assumption that activity influences the attachment size morphology, and on the other reinforced the notion that the entheses architecture acts as a buffer to the muscle activity and are capable of sustaining significant stress levels (Zumwalt, 2006). Amongst the reasons presented for the lack of bony response, was the fact that the subjects studied had a fully mature skeleton. Since adult bone is less sensitive to exercise-induced changes, when compared to younger growing bone, even if subjected to high mechanical demanding performance the bone reaction would not necessarily lead to its "printing" (Turner, 1998). Another important factor to consider is the fact that there is a threshold of bone response, and that bony changes would only be perceived in strains that are beyond this hypothetical threshold. Furthermore there is evidence that this threshold varies between entheses (Zumwalt, 2006). Hence, entheses comparison should only be performed between similar ones, and after determining their resistance threshold to stimuli. Another important aspect referred to was that the attachment sites morphological parameters measured did not reflect muscle size or activity (Zumwalt, 2006).

Until recently, MSM have been used in bioarchaeology to infer activity-specific lesions, differential labour patters, focussing not only in individual lesions but in the overall pattern of enthesopathic lesions in the musculoskeletal system (Capasso *et al.*, 1998; Kennedy, 1989). These approaches were made without reference to entheses heterogeneity and architectural variability, nor even to the simple fact that an enthesis site may reflect the action of conjoint muscles. In all, there has been an oversimplification in bioarchaeology both in the recording, as well as in the interpretation of MSM. It is important to recognise the diversity in entheses, as well as the varied causes behind MSM. When present, are they the result of trauma, degeneration or other pathologies? How much "use", and how intense was the load which originated MSM? Is the overall pattern of MSM found in a skeleton the result of one, or several events of stress? In the end, it is not enough to know the sex, age or even occupation of an individual to determine activity-related MSM. The lack of the complete biography of an individual may hide many important data that will never be accessible, such as when did he/she start working and for how long, did they change jobs/activity, and many more variables. Currently, the perspectives on the aetiology of enthesopaties has also become as complex as that of osteoarthritis.

With regard to osteoarthritis (OA) and MSM analysis in bioarchaeological context, the concept of "bone formers" introduced by Rogers et al. (1997) needs some consideration. It postulates that individuals predisposed to bone forming would progress differently with regards to the presence of osteophytes and enthesopathies due to OA, or other bone forming disease (Rogers *et al.*, 1997). Ultimately, individuals with a higher predisposition to "bone forming" would have a higher correlation between enthesopathies and osteophytes when compared to individuals without that predisposition, if subjected to similar level of stress. Hence, differences in degrees of enthesopathies and osteophytes, would not necessarily reflect differences in stress load but instead the differences in individuals' abilities to "form bone". However, several limitations to the scientific approach of Rogers and colleagues were discussed by D. T. Felson and T. Neogi (2004), one specifically refers to the difficulty of

> the authors to precisely characterize the age of the subjects from whom the specimens were obtained. They managed to differentiate those specimens from subjects <45 years old at the time of death versus those age >45 years. That situation leaves room for much age confounding. In other words, bony changes of OA and extraosseous proliferation both occur with age, and this age confounding could explain much of the association reported (Felson and Neogi, 2004: 342).

Precise age at death determination in a bioarchaeological context is an impossibility. Hence, all inferences based on pathologies that bear some relation with age must be made with caution. Furthermore, Felson and Neogi (2004) state that Rogers and colleagues (1997) were not necessarily describing osteoarthritis proliferation, but instead the predisposition of some individuals to respond with bony growth, such as enthesopathies and osteophytes, to osteoarthritis or even other degenerative diseases (Felson and Neogi, 2004: 342).

But how well can one identify the concept of "bone forming" and "bone losing" in archaeological context (Schimtt *et al.*, 2007), and how much of bioarchaeological research will have to be done so that these new "concepts" can be tested and put into practice? It is important that such inferences should count with the contribution of individuals that may be suffering from spondyloarthropathies, pathologies that may imply a "hypertrophic" response of the musculoskeletal system. In a study on hand bones enthesophytes developed by Kalichman and colleagues (2007), they tested whether the development of enthesophytes was age or/and sex-associated; if enthesophyte development was controlled by genetics; and finally, if there was any correlation between the enthesophytes and osteophytes on the hand joints. The results proved that age was a major factor on enthesopathic development. Age also explained the higher enthesopathic variation in males and in femles (45% *versus 25%*), contributing to 75% of the variation of osteophytes found in both sexes. Genetic components explained 20% of enthesophyte development variation, whilst they found no common additive genetic factors for entheospathies and osteophytes.

The correlation between both bony changes was higher in males, than in females, although statistically significant in both. After age adjustment, the correlation decreased but remained significant. The major conclusion of the authors was that: "Most probably, enthesophytes and osteophytes are manifestations of different etiological processes" (Kalichman *et al.*, 2007: 1).

In summary, and as similarly observed for OA analysis, MSM bioarchaeological investigation requires a re-evaluation of the methods employed in their analysis. As also referred to with OA, there is an urgent need to find better correlations with clinical records, in industrial as well as athletic medicine (Jurmain, 1999; Kennedy, 1989), although ethnographical and historical accounts should also be considered (Kennedy, 1989). Furthermore, one needs address the core of MSM use in bioarchaeology. How much of MSM is explained by activity, if indeed a relation exists at all?

3.2.1.3 Cross-sectional geometry (C-SG) and external diaphyseal measurements (EDM): An overview

Another of the major bioarchaeological parameters of behavioural assessment is the use of cross-sectional geometry (C-SG), as well as external diaphyseal measurements (EDM) of long bones, mostly femur, tibia and humerus. Both EDM and C-SG have been used in the study of biomechanical adaptation of bone to load. Although EDM may be less precise in reflecting biomechanical strength when compared to C-SG, since they do not consider the bone internal architecture, they both provide equivalent results in biomechanical analysis as a reasonable correlation was found between both EDM and C-SG (Larsen, 1997; Ruff, 2000; Stock and Shaw, 2007; Wescott, 2001). The use of C-SG variation amongst archaeological population as indicative of behavioural differences was developed based on biomechanical concepts, pioneered and developed mostly by Ruff and his colleagues (Ruff, 2000; Ruff and Hayes, 1983b, 1983a; Ruff *et al.*, 2006: only a few of the many papers already published).

The research developed by Ruff and colleagues generated a model - the biomechanical model - which has been used ever since as the basis for reconstructing behaviour of past populations. As described by Gillian Bice (2003) the model assumes that differences between C-SG among temporal and/or geographical populations, sexes or even bilateral asymmetry, are a direct result of the levels of physical activity performed. This was based on the premise known as Wolff's law,[23] which can be summarized as the ability of bone to adapt to its mechanical environment. Based on this assumption a relationship between bone architecture and mechanical forces is accepted as highly probable.

The assumptions that bones' C-GS and EDM differences are the result of mechanical stresses became an unquestioned belief in bioarchaeology, as illustrated by many of the published articles (an exhaustive bibliographic review was undertaken by Bice, 2003). However, current research has redirected the use of C-SG from a mere application in bioarchaeology, to a thorough criticism of its principles and use. Although one can accept that bone responds to mechanical stress, the relationship between physical activity and a particular bone response requires further understanding. Instead of attributing the shape and morphological shaft differences solely to physical activity, one should explore the relation between bone architecture

[23] Wolff's law is a theory proposed by Julius Wolff (1835-1902), in the 19th century, in which it was stated that mechanical stress was responsible for determining the architecture of bone and that the form of bone was related to mechanical stress: that is, the strain that bones experience would be responsible for the overall architectural appearance of the bone itself. Wolff's Law has become widely accepted as the foundation for functional adaptation of bone, but as pointed out by M. R. Forwood I and C. H. Tumer: "In the literature, however, it is rarely acknowledged that Wolffs statement on form and function referred to a static mathematical relationship between trabecular architecture and stress trajectories [...] Moreover, Wolff eschewed any knowledge of mechanically adaptive behavior within individuals, believing that the "form" of bone was inherited." (Forwood and Turner, 1995: 197S). Wolff's law has been subject to much scrutiny, such that some authors even advocate that it should no logger be defined as a "law" (Bice, 2003; Forwood and Turner, 1995; Huiskes, 2000; Pearson and Lieberman, 2004; Ruff *et al.*, 2006), and its use should be substituted by referencing to the bone functional adaptation simply as such – *bone functional adaptation* (Ruff *et al.*, 2006). The misconceptions regarding skeletal biology and engineering underpinned much of the discussion about the "law", its meaning and validity as evidence of bone's functional adaptation (Ruff *et al.*, 2006). As already mentioned the proposed substitution of "Wolff's Law" for the term *bone functional adaptation* would avoid the strict mathematical rules of bone modelling and remodelling, perceived as engineered and biologically erroneous; and ultimately grant a more general version of the importance of mechanical loading in the development of bone form (Ruff *et al.*, 2006). This general view integrates two important principles which are the fact that organism posses the ability to adapt their structure to new living conditions, and that cells are capable of responding to local mechanical stress (Ruff *et al.*, 2006).

and bone response to mechanical loading within other frameworks, such as genetics (Bice, 2003; Deme, 2007; Ruff *et al.*, 2006).

> Bioarchaeologists have focused on skeletal mechanics while all but ignoring the biological processes that produce, maintain, and adjust the mechanical properties of bone. Much of the non-anthropological research on skeletal biology suggests alternative explanations for the anthropological findings, and casts doubt on the premises, inferences, and conclusions presented by Ruff, [Clark Spenser] Larsen, [Patricia] Bridges, and others (Bice, 2003: 5).

The bioarchaeological use of C-SG, and to a lesser extent of EDM (since the latter has been superseded in favour of C-SG), has been one of non questioning the biomechanical model and the assumption that it is an excellent representative of past mechanical behaviour, as well as specific physical activities. As suggested by Bice (2003), based on non –anthropological skeletal biology and mechanobiology, the relationship between mechanical loading and bone architecture is complex and variable, and other explanations should be considered when analysing C-SG variability between skeletal groups (Bice, 2003). The fact that bone responds to strain is not questioned, however this functional adaptation is, as it may vary according to location, systematic factors (such as sex, age, genetic background, hormonal statics, and diet), as well as type of strain (Bice, 2003; Cowgill and Hager, 2007; Jurmain, 1999; Owsley, 1991; Ruff *et al.*, 2006). Therefore, one should no longer focus on a "single-cause" approach and focus on a "multiple-cause" model, as the different factors may very well interact between themselves in the production of the C-SG variation (Bice, 2003). The "multi-cause" effect approach has also been advocated to assess osteoarthritis and MSM (Jurmain, 1999; Waldron, 2001; Wilczak and Kennedy, 1989). Ultimately, although inferences can be made with regard to activity levels,[24] these should always be contextualized and cautiously addressed. The key issues is that that C-SG studies should be less generalized, because results

[24] For instance, bone remodeling appears to be related to physical activity as demonstrated in many studies that focus in sports activities (in Maïmoun *et al.*, 2004); however the results are not as clear-cut as expected, as proven by Maïmoun and colleagues (2004). They tested the effect on bone remodeling of physical activities which induced moderate external loading on the skeleton and only found osteogenic effect in triathletes athletes, but such results were not attainable for cyclist or swimmers. Although bone remodeling was accounted for in the athletes when compared to the control groups, the authors also conclude that the observations are not enough to state that changes in bone remodeling were sport dependent (Maïmoun *et al.*, 2004).

obtained in a specific dataset, or experiment, do not necessarily relate to other chronological and geographical settings, nor experiments. Comparative issues are not only limited to population comparison, but also between the skeletal elements themselves, as proven by Peck and Stout (2007).

Peck and Stout (2007) tested the hypothesis that the existent heterogeneity found in bone mass was caused by specific mechanical load environment to which each skeletal element was exposed. Age, sex and pathological status were correlated with cortical cross-sectional area measurements of several long bones. The results showed that bone mass was highly variable amongst individuals, correlating with sex and ancestry, as well as with socio-cultural and life-style factors (Peck and Stout, 2007). The research also showed that intra-skeletal variability was specific to the bones of the upper and lower limbs. Femurs and tibiae were exclusively similar to each other, understandably, as these are the primary weight bearing bones, whilst fibulas were similar to ulnas. In the upper limb, radii exhibited substantial higher bony mass when compared to the other upper limb bones, whilst humerus exhibited substantial lower bone mass. With regard to inter-skeleton variability, bony mass may be related to diet, hormones, genetics, as well as differential mechanical loads (Peck and Stout, 2007). Based on these results, and due to the amount of factors that can interfere with bone mass variability between populations, if one is to test differences between mechanical load, intra-skeletal variability may be one of the major factors of differentiation since it would allow for controls in sex, age, diet and other variables.

In conclusion, in the sample analysed by the authors, bone mass in the tibiae and femurs correlated because of their shared role as the primary weight bearing bones, with similar loading environments. On the other hand, the bone mass variability found between bones of the upper limb attested its differentiation in function. The authors also found no significant differences between sexes, despite the fact that males had on average higher bony mass than females. This result is suggestive that similar activity was being practiced by both males and females with differing overall magnitude between bones. These results are important because they provide an experimental basis for further testing, the assumption being that "when clearly defined sexual divisions in physical activity exist, the degree of intraskeletal variability should differ between the sexes. However, these differences will only manifest if the activities practiced affect different bones with sufficient magnitude and frequency" (Peck and Stout, 2007: 93). Furthermore, the authors also ascertained that age differences were only "visible" when the sample was divided into two major groups: young individuals (age $\leq$ 50) and older individuals (age $\geq$ 50). The amount of bone loss between these age categories was constant with the exception of femurs and tibiae, where only a slight decline was observed in the second group, with age-related bone mass being less in weight bearing bones (Peck and Stout, 2007). This later finding is of enormous importance for bioarchaeology. The division of samples into such large age groups avoids many problematic issues related with age at death assessment in archaeological records, making the study replicable in the archaeological record, as well as comparable.

The importance of age as a variable in the bone morphology requires supplementary research on the impact of activity in early life, as stated by Osbjorn Person and Daniel Lieberman: "There is a crucial need for more data on response to mechanical stresses in children and teenagers, both in living as well as in skeletal samples of ancient children" (Pearson and Lieberman, 2004: 90), as research has shown that adults' response to mechanical loading is slower than in younger individuals, thus long–term longitudinal studies may be necessary to clearly document changes through age (Ruff *et al.*, 2006). Bone maintenance in adulthood is also dependent on continuation of "normal" mechanical loading reaction, which is established early in their development. Hence, variation in adult bone morphology will also reflect differential adult behaviour, which would reflect a person´s long history of behaviour pattern (Ruff *et al.*, 2006). If one was to properly assess bone mechanical constrains, and its influence on bone shape and morphology, one would necessarily need to account for individual life history, and seriously consider longitudinal studies.

From a bioarchaeological point of view long–term longitudinal studies are not possible, however alternatives exist. For instant, it is possible to test a simple assumption as: that the greater the C-SG differences, or bilateral asymmetry, the higher the probability of individuals being engaged in differential mechanical loadings. This could be tested if one was to consider individuals of the same sex, of the same population and with access to similar diet. Similarity in diet can be inferred through the use of isotope analysis. The fact that only two major age groups would be acceptable to test this hypothesis (as shown by Peck and Stout, 2007) comfortably fits the profile of many archaeological populations. This "draft-like" proposal is one example of how C-SG differences and bilateral asymmetry can be evaluated in future studies. It almost looks ideal, however one would still need to account for other variables. Additionally, this type of study-model would be populational and sex limited.

The bioarchaeological use of cross-sectional geometry, or whole (external) bone measurements have been used to infer behaviour in past human societies (Larsen, 1997).[25] Authors believe that behavioural inferences can be drawn from general pictures of robusticity and flattening of certain bones, and that difference in shape and morphology are based on the functional argument. For example, external dimensions and comparisons of right and left side bones can be used to infer differential use of limbs in activities. This is also the case of studies done on the upper arm, or more specifically with the humerii (Rhodes and Knüsel, 2005; Stirland, 1993). For instance, the flattening of long bone diaphyses would be the effects of specific muscles, or muscle groups actions on the diaphyseal morphology (Knüsel, 2000; Larsen, 1997). With regard to femoral and tibial midshaft diaphyses, the respective platymeric and platycnemic indices tend to be lower in more mechanically stressed populations than in lesser mechanical stressed populations; it indicates relatively greater anteroposterior bending forces in the upper and lower legs (Knüsel, 2000; Larsen, 1997). In summary, therefore, long bone diaphyses are believed to be highly responsive to the mechanical environment, and external shaft dimension / measures of bone, or its volume, allow inferences about patterns of activity (Knüsel, 2000; Larsen, 1997). However, more recent studies have questioned these assumptions; not necessarily in the ability to infer activity based on dyaphyseal changes, but specifically the manner in which studies have been performed. The major criticisms focus particularly on the fact that population comparisons have been

[25] Some of the most recent studies undertaken in C-GS include studies in regional variation (Shackelford, 2007; Wescott, 2006); ontogeny of postcranial robusticity (Cowgill and Hager, 2007); gender differences, and subsistence changes (Sládek *et al.*, 2007); changes in long bone architecture, asymmetry, and sexual dimorphism associated with intensification of horticulture (Wescott and Cunningham, 2006); different patterns of mobility, climatic adaptation and selection for tissue economy between hunter-gatherer population (Stock, 2006); analysis of cross-sectional robusticity and asymmetry from 18th century Quebec prisoners of war, and 20th century sample from New Mexico (Weiss, 2005). All of these studies briefly address, and refer to, more classical literature on the matter.

made between unrelated cultural and biological populations, denying the correct framework for comparisons (Wescott, 2001, 2006; Wescott and Cunningham, 2006).

Therefore, despite the continuous discussion about the use of S-CG and EDM in the assessment of human behaviour, and the clear demonstration of its limitation (Bice, 2003; Ruff *et al.*, 2006), these continue to be used as proxies of functional adaptive changes of bone structure as consequence of mechanical loading. One should be aware that the problems go far beyond the scope of determining the importance, or the effects of multiple variables such as age, sex, genetic, function, diet and even simply morphology. Although, not discussed in the present research, there are also methodological issues which should be addressed. These are particularly related with the quality of the C-SG and external diaphyseal measurements (Stirland, 1994). In the end, it is clear that to assess any type of C-SG changes and establish a relation between those and activity alone may be a difficult task. Whatever conclusion one may draw need to be interpreted accordingly with the nature of the data, and one should try to avoid generalistic and simplistic conclusions. In the end, a safer approach may be more reliable, even if one's conclusions are inconclusive. That being the case, the only option is to construct an educated theoretical model, which can fit the data under analysis, and hence produce reliable conclusions.

3.2.1.4 Other Markers of Occupational stress (O.MOS): A brief overview

There are other osteological changes that have been used to assess behavioural changes in past human populations. These comprise trauma, periostitis and vertebral lesions such as Schmorl's nodes and spondylolysis (Capasso *et al.*, 1998; Jurmain, 1999; Larsen, 1997, 2002, 2006; Roberts and Manchester, 2005). Traumatic lesions are amongst the most easily observed, and diagnosable, in the archaeological record (Jurmain, 1999; Ortner, 2003). Some traumatic lesions can provide unambiguous evidence of behaviour, especially when related to interpersonal violence. The given example, of an embedded projectile is usually obvious (Jurmain, 1999: 214). Accidental injury, reflecting daily living, would suggest a completely different behaviour to intentional and interpersonal violence. The presence of factures on the lower leg (tibia, fibula), clavicle, ribs, upper arm (humerus), and hip (especially the femoral neck) have been recorded in many archaeological populations and associated with activity and/or behaviour (Jurmain, 1999; Larsen, 1997; Nystrom and Buikstra, 2005; Ortner, 2003; Paine *et al.*, 2007; Tung, 2007: to name only a few studies).

The analysis of periostitis as activity related bears a close relation with the clinical tibial stress syndrome (Bouché and Johnson, 2007; Pell *et al.*, 2004). This syndrome is one of the most common lower-extremity overuse injuries, and has been associated with recreational and professional athletes who compete in running sports (Pell *et al.*, 2004). The cause of this tibial stress syndrome is unclear, and changes in bone metabolism are likely to be involved, but its pathomechanics may be related with mechanical strain associated with the tibial fascia (adjacent to its distal medial crest insertion) (Bouché and Johnson, 2007; Michael and Holder, 1985). Bone remodelling is one of the characteristics of tibial stress syndrome (Gaeta *et al.*, 2006), and it is precisely these changes that are observed in osteological material. Some periostitis reaction present in osteological material may have causes other than activity. For instance, there are some periostitic lesions associated with specific infectious such as tuberculosis, tumours, leprosy and other pathologies (Aufderheide and Rodríguez-Martín, 1998; Dale *et al.*, 2001; Matos and Santos, 2006; Ortner, 2003; Santos and Roberts, 2006; Sulzbacher *et al.*, 2000; Waldron, 1997a). Therefore, periostitis may be the primary response to local pathologies, in which one may include trauma, or to systemic infection and metabolic disorders (Aufderheide and Rodríguez-Martín, 1998; Fennel and Trinkaus, 1997; Ortner, 2003; Ortner and Putschar, 1985).

Spondylolysis[26] is another pathology that has been used to assess behaviour. Some researchers assume that it is an inherited condition; however, a more compelling explanation is that spondylolysis is a type of stress fracture, and although some individuals may have a higher predisposition to develop the pathology, it will develop as a secondary effect of trauma. Spondylolysis frequency was highly observed in individuals involved in mechanically demanding activities which

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[26] *Spondylolysis* is a defect found on the pars interarticularis of the vertebra, usually on the 4th and 5th lumbar. The lesion may be either unilateral or bilateral. In cases where the defect is bilateral, the "slipping forward" of the vertebra body, over the underlying vertebra may occur: this condition is named 'spondylolisthesis' (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003).

supports the mechanical stress model, but it is also seen in industrial populations engaged in activities with lower demanding physical exertions (Capasso *et al.*, 1998; Jurmain, 1999; Larsen, 1997; Merbs, 1996b, 1996a, 2002a, 2002b).

Schmorl's Nodes correspond to disc herniations through the cartilaginous vertebral body endplates (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003). They are commonly associated with elderly segments of the population; however they are also reported in younger individuals. Schmorl's nodes may be caused by cause by as numerous factors as trauma, hyperparathyroidism, osteoporosis, Schuermann's disease, osteomalacia, infections, and neoplasm (Yochum *et al.*, 1994). Bioarchaeologically, they have been mostly associated with activity, and activity related injuries (Capasso *et al.*, 1998; Larsen, 1997). A clinical and archaeological overview on Schmorl's Nodes was recently compiled by J McNaught (2006).

The bioarchaeological and clinical literature on the above MOS has already been widely discussed (Aufderheide and Rodríguez-Martín, 1998; Fibiger and Knüsel, 2005; Mays, 2007; McNaught, 2006; Merbs, 2002a). All of them have been used to assess activity in archaeological record, and in bioarchaeological records this association was observed in many studies (see the following authors for a brief overview on the pathologies mentioned: Arriaza, 1997; Capasso *et al.*, 1998; Mays, 2007; Merbs, 1996a, 1996b). In all, the bioarchaeological approach has been mostly one of single cause, although that does not correspond to reality (Yochum *et al.*, 1994).

From a bioarchaeological point of view their study as skeletal indicators of "status", health and activity is still widely used (Belcastro *et al.*, 2007; Robb *et al.*, 2001), and it is as a markers of activity that they will be discussed in the present research. However, this does not imply that the single-effect, in this case activity, is defended in this research. The objective is ultimately to present the results from an occupational/activity-related point of view, and hopefully develop a parallel research in which additional variables may be considered and explored in future studies. The awareness of the need of further research into this matter was a primary consequence of the research undertaken. Once more, the holistic approach defended by Jurmain (1999) and Waldron (2001) is regarded as the only option for future bioarchaeological research on MOS, or any other pathological study performed/based on skeletal material.

3.3 Summary conclusions

The major conclusion drawn from the general overview is that all MOS seem to be related to a multitude of factors that are impossible to account for in a bioarchaeological context. One can determine sex, with reasonable certainty, and age at death to a much lesser degree, and body mass has also become a factor determinable in bioarchaeology, although not without some reservations. Unfortunately, there are still many other factors that are unfeasible to ascertain, hence, as worded by Cynthia Wilczak: "the critical question is whether or not these individual factors can be isolated so that the actual stress-related changes can be distinguished" (Wilczak, 1998: 312). Studies addressed by Elizabeth Weiss (2004, 2003) have already demonstrated that sex differences in MSM robusticity may be related with body size, rather than activity. Diet, fitness and the amount of time an individual have been engaged in a particular activity may also influence the overall skeletal robusticity (Peck and Stout, 2007; Stirland, 1998). Finally, nowadays bioarchaeological studies on MOS face the following challenges: firstly, the necessity to revise the methods employed in MOS assessment; secondly, bioarchaeologists need to undermine generalist approaches to MOS conclusions; thirdly, it is necessary that any interpretation drawn from bioarchaeological studies are populationally, geographically and historically contained, particularly if those variables cannot be accounted for; fourthly, any analysis of degenerative MOS needs to convey, as far as possible, the notion of "individual life history", without doing so, such an honest assessment of the MSM or OA is impossible; finally, there is an urgent need to correlate the finding and methodologies with clinical data. Consequently, bioarchaeological studies of activity-related stress, or activity-specific are as reliable as the number of confounding variables one can account for. That is to say, the less one knows about an archaeological sample, the less we can infer, and consequently the less reliable are the results obtained.

3.4 Bioarchaeological studies on markers of occupational stress

This section illustrates some of the development of bioarchaeological studies under the umbrella of MOS. This is a very brief overview of some of the more classical, and recent papers. The objective of the section is purely to demonstrate the chronological and geographical range of the research being undertaken. The studies here presented were conducted using osteoarthritis (OA), degenerative joint disease (DJD), markers of occupational stress (MSM), or a combination of several MOS. Their overall objective was to assess activity/occupational related patterns, or behavioural patterns in past human populations. The studies are presented according to date of publication. The chronological and geographical settings, as well as major conclusions are presented.

In 1983 Charles Merbs observed in the Sadlermiut Eskimo, from the Northwest Territories, that adult males frequently had osteoarthritis on both acromio-clavicular joints, and had highly developed arm muscles. On the other hand adult females presented severe degenerative changes in the temporomandibular joint. The degenerative changes observed in the males were referred to as being most probably due to kayaking. The severity of change found in women was probably the result of repeated extra stress on the joints of the jaw. According to ethnographic evidence the extra stress on the jaw would results from the fact they were using the teeth for the softening of leather and animal hides by chewing them (Merbs, 1983).

Robert Jurmain, in 1989, compared the patterns of osteoarthritis in skeletons from the southeastern San Francisco Bay area. The sample dated from AD 500 up to pre-European contact, and also included skeletons of settled agriculturists from Pecos

Pueblo, New Mexico. Jurmain found that the pre-agriculture group had more joint disease than the agricultural groups, suggesting that the hunter-gatherer lifestyle placed greater stresses on the joints (Jurmain, 1989).

Patricia Bridges examined the degenerative joint disease of the major appendicular joints of hunter-gatherers and agriculturalists from northwestern Alabama. Bridges found a practical absence of sex differences in the hunter-gatherer group, which contrasted with the severe OA found in male agriculturalists (in comparison to females). These results conflicted with the biomechanical evidence, which indicated an increase in usual activities in the agricultural period. The explanation presented for the contradiction was the possibility of OA being the result of intensive and/or infrequent activities (Bridges, 1991).

The analysis of muscular stress markers in Spanish peasant populations, from a medieval context (6th and 12th centuries AD), revealed that a high level of MSM was compatible with strenuous daily activities. These activities would have included carrying heavy loads, cattle raising, farming and hunting (Galera and Garralda, 1993).

Human skeletal material from the Iron Age cemetery at Pontecagnano (VII-IV century BC, Italy) was used to demonstrate skeletal activity-related traits associated with high mobility. Amongst them were included MSM, OA and biomechanical structural adaptation as well as other MOS such as trauma and tibial periostitis (Robb, 1994).

The increase in the level of physical stress, particularly in the Achilles tendon, was used to assess differences between samples of rural and urban provenance. The samples under analysis were from the Late Bronze Age, in South West France, and two samples of medieval provenance. One from Canac, of the rural provenance, and another of St Etienne, of urban origin (Casas *et al.*, 1996).

The results of the analysis of markers of occupational stress in a sample from the Lucus Feroniae, a rural low town of the Roman Imperial age (1st and 2nd centuries AD), showed that this population was most probably composed by individuals of low social group, employed in heavy manual work compatible with farming tasks (Sperduti, 1997).

Knüsel and colleagues (1997) assessed skeletons from the thirteenth to fourteenth century medieval priory cemetery of St. Andrew, Fishergate, York, for patterns of degenerative joint diseases (DJD) of the intervertebral, and apophyseal joints of the vertebral column. The study revealed a conflict of sources: the archaeological context and ethnohistorical data indicated that individuals of different social status were buried in medieval cemetery. Therefore, differences in the pattern of degenerative lesions were expected to be found. However, no statistically significant difference between the samples was found. The conclusion draw by the authors was that the analysis of DJD, of the vertebral column, might not be ideal to study the effects of normal activity patterns, and that the changes most probably resulted as a response to erect posture during bipedal locomotion, rather than differential occupational stresses (Knusel *et al.*, 1997). Similar observation had already been made by Patricia Bridges (1993) in a skeletal sample from prehistoric Native Americans of north-western Alabama. Bridges found that the patterning of OA found in the vertebral column was most probably the reflection of stresses imposed by erect posture and weight-bearing in the spinal curvature and was not necessarily related with activity. However, she admitted that the "carrying of burdens" using a tumpline could have been involved in the development of cervical ostheophytosis (Bridges, 1993b). Human biomechanical adaptation to bipedal locomotion as a stress factor to the vertebral column was also reported by Jurmain (2000). The analysis of DJD in great apes, from the Gombe National Park, Tanzania, and a human sample revealed that the apes exhibited less significant DJD in the vertebrae in comparison to humans. The same observation was achieved for the major peripheral joints (Jurmain, 2000).

The analysis of two Alaskan Eskimo skeletal series, from Golovin Bay and Nunivak Island, showed MSM sex-related differences. Significant differences were also within women's sub-populations. In this latter case females of the Golovin Bay sample utilized certain muscles of mastication more than the females of the Nunivak Island sample. The explanation given was that the former female sub-sample were using their jaws to chew animals skins used in the manufacture of footwear. All other similarities, and differences in MSM expression found, were explained as consequences of the unique subsistence strategies, and habitual daily activities (Steen and Lane, 1998).

Sofaer Derevenski (2000) inferred that pattern of OA found in the vertebral columns of women from Ensay, in the Outer Hebrides, was probably related with the habitual carrying of heavy loads on the backs. This specific "activity" was done using baskets. This would result in a peculiar posture, with alterations to the normal contours of the vertebral column, and ultimately in differential levels of OA (Derevenski, 2000).

The study of human osteological remains recovered from Alepotrypa Cave, a site occupied between 5000–3200 BC, revealed that OA and MSM were indicative of increased physical activity and heavy workloads (Papathanasiou, 2005).

MSM analysed in the human remains of several ancient populations of the Iberian Peninsula, ranging from Early Copper Age to Medieval Epoch (2800BC – 1300AD), pointed to ecological and socio-cultural factors as the major differential factors between populations. The results obtained agreed with the historical and archaeological data available (al-Oumaoui *et al.*, 2004).

Eshed and colleagues (2004) quantification of changes in activity patterns of early farming populations in the Levant, from the transition of hunter-gatherer to agriculture, increased the mechanical stresses on the upper limb in Neolithic populations when compared to the hunter-gatherer populations. The MSM pattern found also indicated a gender-based division of labour both in the Natufian (hunter-gatherer), as well as on the Neolithic populations. The results also suggested that people in the Neolithic period were engaged in different (new) activities and occupations when compared to the Natufian (hunter-gatherer) (Eshed *et al.*, 2004).

The analyses of a skeletal sample from Ajvide, Gotland, a Middle Neolithic (2750–2300 BC) burial ground, revealed the presence of several significant positive correlations between musculoskeletal changes and specific prehistoric activities. These correlations were found for male adults. Archery and harpooning were included amount their activities. Correlation was also tested for Kayaking, but this revealed to be non significant (Molnar, 2006).

Lieverse and colleagues (2007) analysed a sample of five cemetery populations representing the pre-hiatus Kitoi culture (6800–4900 BC), and the post-hiatus Serovo-Glaskovo (4200–1000 BC). The authors reconstructed mobility and activity patterns among the Cis-Baikal foragers by means of OA. The data revealed that activity patterns were relatively constant all through the periods in question, whereas mobility and other specific activity patterns were not (Lieverse *et al.*, 2007).

Chapter 4: Methods

This chapter details the methods used in present research. It is divided into three major sections. The first section addresses the methods selected for the osteological data collection. The second section refers to the statistical tests selected for the analysis. The third section concerns the results of inter and intra-observer error testing.

The osteological data collection refers to the analysis of the markers of occupational stress (MOS) selected. The MOS used in the present research were chosen based on previous studies that focused on the analysis of behaviour and activity-related patterns in past-human populations. These were already widely discussed in the previous chapter. The MOS used were degenerative bony changes (DBC) in the joints articular surfaces, and osteoarthritis diagnosis; musculoskeletal stress markers (MSM); external diaphyseal dimension of long bones (EDM), converted into postcranial indices; and the presence of trauma, tibial periostitis, Schmorl's nodes in the vertebral bodies, as well as spondylolysis in the lumbar vertebrae (Capasso *et al.*, 1998; Hawkey, 1998; Hawkey and Merbs, 1995; Jurmain, 1999; Kennedy, 1989; Knüsel, 2000; Larsen, 1997; Rogers and Waldron, 1995). Whilst describing the methods of analysis, additional information will be provided regarding alterations made to the original proposed approach. That is, in the process of the application of the methods originally selected for data collection, some revealed to be either subjective during recording, or not explicit enough with regards to their description. Consequently, adjustments were made to adapt the methods to the data collected. This was done bearing in mind the primary aim of the research, which was to explore the potential of studying gender differences from a palaeopathological perspective.

The statistical analysis description is divided into two sections. The first addresses the statistical tests used in the analysis of the variables originally recorded, whilst the second section reports on the statistical tests performed on the grouped variables created from the original set of data. Although the statistical tests performed are detailed here, the explanation and description of the methods employed in the creation of these variables will be presented in the discussion of the first set of results (Chapter 6). This will allow for the contextualization and justification of this course of action.

Finally, the end section of the chapter focus on inter and intra-observer error measurements. Initially the data collection is described, with mentioned of the material used in the replication of the bioarchaeological analysis and statistical test used. Finally, the statistical results of inter and intra-observer error are presented.

4.1 Methods I: Osteological data collection

4.1.1 Degenerative bony changes (DBC)

4.1.1.1 Data collection

The degenerative bony changes (DBC) collected were marginal lipping (used specifically as synonym of changes occurring around the joint rim), porosity, eburnation and osteophytes on the articular surface. Each articular surface of each joint was examined separately for evidence of any of the bony changes. The joint surfaces analysed were the acromioclavicular joint (the acromial articular surface of the scapula and clavicle), the shoulder (the surfaces of the glenoid fossa and humerus), the elbow (the surfaces of the distal humerus, proximal radius and ulna), the wrist (the distal surfaces of the radius and ulna), the hand (first carpometacarpal joint), the hip (the femoral head and acetabulum), the knee (the surfaces of the patella, distal femur, and proximal tibia), and the ankle (the surfaces of the distal tibia and fibula). Right and left side articular surfaces were examined separately.

4.1.1.2 Methods of analysis

The assessment of DBC followed the recording protocol proposed by Buikstra and Ubelaker (1994) (Table 2, Figure 3 and 4).

Table 2 – Description, and degree of the lesions used to record the DBC.

Degenerative changes	Description	Grade	Degenerative changes	Description	Grade
lipping	absent	0	**surface porosity**	absent	0
	barely discernible	1		pinpoint	1
	sharp ridge, some times curle with spicules	2		coalesced	2
	extensive spicule formation	3		both pinpoint and coalescent	3
	ankylosis	4			
surface osteophytes	absent	0	**eburnation**	absent	0
	barely discernible	1		barely discernible	1
	clearly present	2		polish only	2
				polish with groove (s)	3

Figure 3 – Examples of DBC recorded on the proximal end of tibiae. From left to right (1-4): 1) extensive marginal lipping with porosity and eburnation characterised as "polished with grooves" on the medial condyle; 2) presence of marginal lipping of grade 2, where a distinctive sharp ridge can be observed; 3) marginal lipping barely discernible on the anterior border of the lateral condyle; 4) marginal lipping barely discernible accompanied with micro-porosity.

Figure 4 – Examples of DBC recorded on the *patella* articular surface. From left to right (1-4): 1) marginal lipping with extensive spicule formation and a wide eburnated area, with a significant amount of groves/porosity; 2) marginal lipping sharply ridged; 3) barely discernible marginal lipping; 4) osteophyte clearly present on the articular surface.

The analysis of the DBC was done in two steps. Firstly, the bony changes were evaluated for each joint surface separately. Both ordinal data (degree of lesions) as well as dichotomous data (presence or absence of lesion) were tested. Secondly, all joint surfaces were combined into the corresponding major articulations (e.g.; shoulder; elbow, wrist, hip, knee and ankle). The latter was done so that the diagnosis of osteoarthritis (OA) could be performed. OA variable was translated as Presence/Absence according to compound joints.

The positive diagnosis of OA followed the method described by Rogers and colleagues (Rogers, 2000; Rogers and Waldron, 1995; Rogers *et al.*, 1987). The presence of eburnation, on any individual articular surface, was sufficient for a positive identification of OA in a particular joint. In its absence, the presence of any two of the following DBC was sufficient to classify a joint as osteoarthritic (see Figures 3 – 5 for examples):

- New bone around the joint margin (lipping) – grades 2 or more. The presence of "barely discernible" marginal lipping was not considered in the diagnosis of OA.
- New bone on the joint surface (osteophyte) – grade 1 to 3
- Porosity on the joint surface – grade 1 to 3
- Eburnation – grade 1 to 3

The reason why "barely discernible" marginal lipping was not considered in the diagnosis of OA, relates to the ambiguity of its origin and morphology. For some authors the presence of this type of lesions may be related to age senescence of the joint, and not necessarily with a pathological process. Furthermore, in the current research, "barely discernible" changes corresponded to a very slight alteration on the margin of the articular surface. These changes sometimes lacked characteristic degenerative ridge formation (Figure 5.3), having an edge that could be described as a "smooth and convex" (Figure 5.4). In this particular case marginal lipping is very negligible, one may even argue that if "marginal lipping" implies the necessity of some sort of sharp-ridge, such condition is absent in this case, and therefore the changes observed should be disregarded as DBC. However, one may also argue that despite its "discrete" appearance, there is undoubtedly a change present and this should be accounted for. In the present study, cases such as these were recorded as "barely discernible" and included in the overall assessment of DBC, but disregarded as a diagnostic criterion for OA.

The major conclusion of this brief discussion is that, although "barely discernible" can sometimes represent normal morphological variations of the bone surface, only an experienced bioarchaeologist can potentially distinguished between both. Therefore, their interpretation is directly related with the experience of the researcher. The importance of "experience" in the assessment of degenerative bony changes was already addressed by Tony Waldron and Juliet Rogers (1991). Their study revealed that beginner researchers and experienced ones may disagree in their evaluation of degenerative bony changes, as well as in the diagnosis of OA (Waldron and Rogers, 1991). Consequently, it would be of enormous advantage, and utility to develop an osteological atlas for all the DBC observable in the different human articular surfaces. This would provide an osteological reference atlas, similar to the ones existing for the radiological coding of OA in clinical studies (Altman and Gold, 2007; Kellgren and Lawrence, 1957a). This would provide an excellent model for comparison, and standardization of DBC recording.

Figure 5 – The grades of marginal lipping found throughout the articular surfaces were comparable to the ones shown in this Figure – humerus head. From left to right (1-4): 1) marginal lipping with extensive spicule formation. Additionally, this surface also had severe eburnation, with extensive porosity; 2) marginal lipping with sharp ridges, slightly curled in some areas. An osteophyte is also visible on the articular surface; 3) presence of barely discernible marginal lipping – distinct sharp ridge, although small; 4) ambiguous case of barely discernible marginal lipping. Although there is not a clear bony ridge formation, there is a clear delimited area on the edge of the articular surface – described here as a "smoothed-convex-edge".

Evidence of OA in any of the joint anatomical compartments was sufficient to consider the joint affected with OA. Diagnosis of OA was performed for all available joints. A joint was considered eligible for analysis provided that at least half of any joint surface was available for inspection (Figure 6, left). If, due to post-mortem damage, the articular surfaces recovered corresponded to less than half of any joint surface, the joint itself was considered a "missing value" (Figure 6, right).

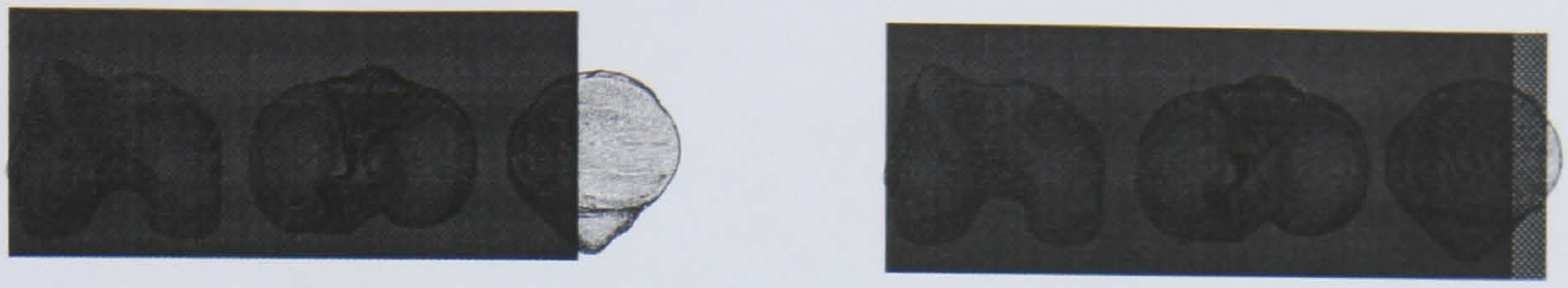

Figure 6 – The schemes represent the three anatomical compartments of the knee joint. The shaded areas correspond to non-recovered/preserved articular surfaces. Left: only half the patellar articular surface was available for observation. If DBC observable in this fragment were compatible with a positive diagnosis of OA, the corresponding knee joint would have been considered affected. On the other hand if no DBC compatible with OA diagnosis were present, the joint would have been considered "healthy". Right: only small lateral fragments of the articular patellar surface were recovered. Because the fragments represent less than 50% of the lateral articular surface of the patella, the correspondong knee joint would have been considered missing.

4.1.2 Musculoskeletal stress markers (MSM)

4.1.2.1 Data collection

A total of 28 entheses were selected for MSM analysis. The entheses selection was based on previous bioarchaeological studies. The aim of such choice of procedure was to conduct a future comparative study between populations. However, during the course of the research it become apparent that entheses sites are complex "organs", that can be influenced by neighbouring entheses, as well as adjacent joints (see section: 3.2.1.2_Chapter 3 for details). For example, initially the aim was to record the entheses of the *Latissimus dorsi*, *Teres major* and *Pectoralis major* muscle separately. All of theses are located in the surgical neck region (Figure 7). However, during the recording process, it became evident that in some cases the degree of changes observed in those areas were blurring the boundaries of each enthesis, complicating the analysis process. Furthermore, the awareness that changes in that area (as well as others) was the result of the actions of several muscles, demanded a more holistic perspective on the interpretation of the lesions on the sites observed.

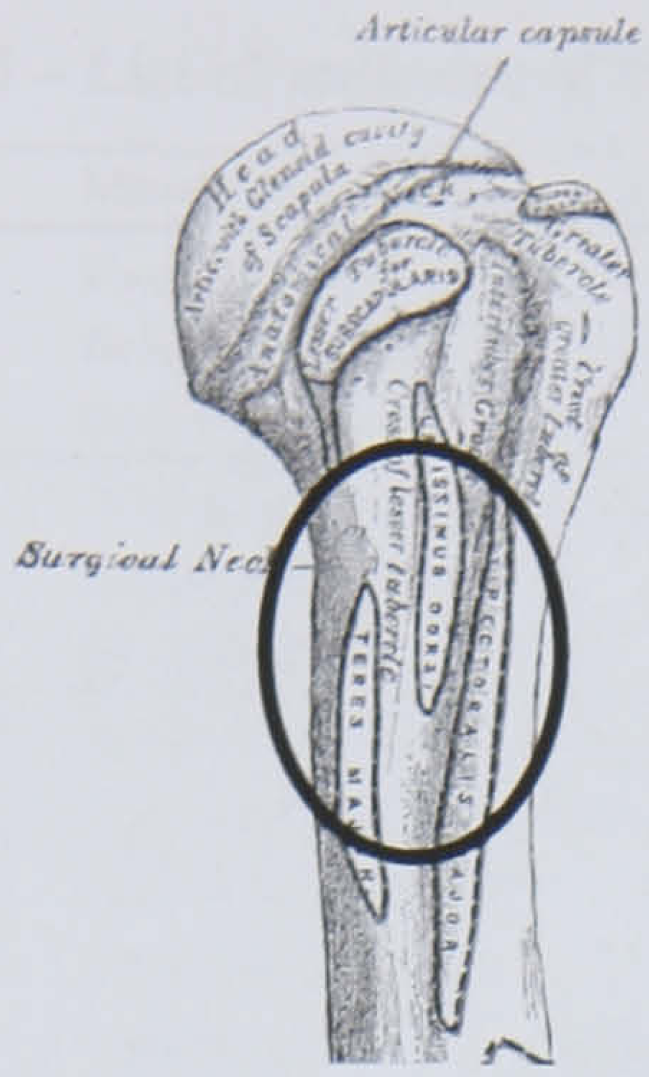

Figure 7 – Surgical neck of the humerus showing the *Latissimus dorsi*, *Teres major* and *Pectoralis major* entheses sites (adapted from (Gray, 2005 (1918): http://www.bartleby.com/107/illus207.html)

Hence, in the final recording method MSM were recognized not according to entheses, but according to osteological sites such as the coracoid process in the scapula, and the surgical neck of the humerus (depicted in Figure 7). This procedure eliminated some of the concerns regarding the exact limits/boundaries of the entheses. It also conveyed a more realistic/holistic perspective of the body/skeleton as an interconnected organ, where changes observed in one *locus* may be the result of several contributors. Ultimately, this concern for a holistic perspective determined the creation of the "Grouped_Variables", where data on DBC and MSM were pooled together, according to joint, limb and individual.

Table 3 lists the original entheses considered for observation, and the corresponding *locus* in the bone which were used in the presentation of the data and its interpretation. The numbers in the last column represent the coding attributed to each anatomical site.

Table 3 – List of entheses of the upper and lower limbs.

Bone	Muscle / ligament	Locus in bone	
Clavicle	*Trapezius muscle*	Superior surface - acromial extremity	1
	Deltoideus muscle	Superior surface - acromial extremity	2
	Costoclavicular ligament	Impression for costoclavicular ligament	3
Scapula	Conoid ligament and trapezoid ligament of coraco-clavicular ligament	Corocoid process	4
	Deltoideus muscle	Acromion	5
	Trapezius muscle	Acromion	6
Humerus	*Latissumus dorsi, pectoralis major* and *Teres major*	Surgical neck	7
	Supraspinatus and Infraspinatus muscle	Greater tubercle	8
	Subscapularis muscle	Lesser tubercle	9
	Deltoideus muscle	Deltoid tuberosity	10
	Common extensor origin and *Anconeus*	Lateral epicondyle	11
	Common flexor origin	Medial epicondyle	12
Radius	*Biceps brachii muscle*	Radial tuberosity	13
	Pronator teres	Interosseous border - rough area for *Pronator teres*	14
Ulna	*Triceps brachii / Anconeus muscle*	Olecranon	15
	Brachialis muscle	Ulna tuberosity	16
Os coxae	Extensor muscles of the thigh	*Ischium* tuberosity	17
	External oblique ligament	Iliac crest	18
Femur	*Gluteus minimus / Gluteus medius muscles / Piriformis*	Greater trocanter	19
	Gluteus maximus muscle	Gluteal tuberosity	20
	Insertion of adductors: *longis, brevis* and *magnus*	Linea aspera	21
	Medial head of *gastrocnemius*	Medial supracondylar line	22
Tibia	Patellar ligament	Anterior tuberosity	23
	Soleus muscle	Soleal line	24
	Interosseous ligament (Tibiofibular ligament)	Fibular notch	25
Calcaneus	Calcaneal (achilles) tendon	Posterior surface of calcaneus	26
	Intrinsic muscles (several)	Plantar surface	27
Patella	*Rectus femoris* and *Vastus intermedius* of quadriceps tendon	Base of anterior surface	28

4.1.2.2 Methods of analysis

MSM were scored using the methodology developed by Hawkey and Merbs (1995). The authors enumerate three main categories of lesions: robusticity marker (RM); stress lesion (SL) and ossification exostosis (OE) (Hawkey and Merbs, 1995). According to the authors, each category represents a different type of musculoskeletal stress marker expression: the robusticity markers describe the normal reaction of the skeleton to habitual muscle usage, and reflect daily activities that produce rugged markings at the skeletal site of attachment. It is seen in its most extreme expression as sharp ridges or crests of bone. The stress lesions are defined by the authors as pitting or a "furrow" in the cortex, to the degree that it superficially resembles a lytic lesion. The ossification exostoses represent an exostosis, or bony spur, that results from a new bone formation due to abrupt macrotrauma. Each category was given four grades of lesion expression: absence (0), faint (1), moderate (2) and strong (3) (Hawkey and Merbs, 1995) (Figure 8).

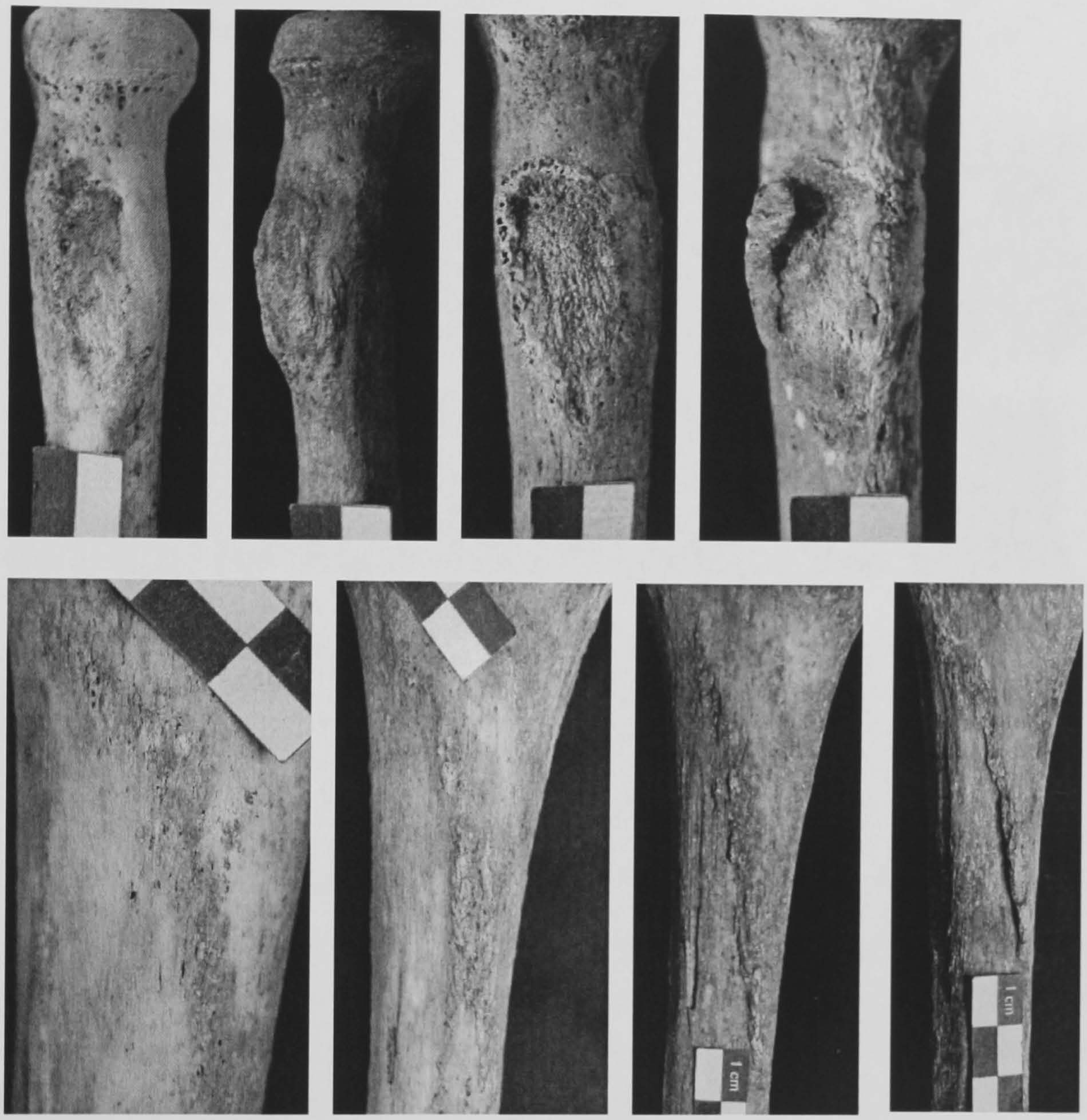

Figure 8 – Varying robusticity markers degrees for the *Biceps brachii* (top) and for the *Soleus muscle* (bottom) insertion sites. Grades 0 to 3 from left to right.

The use of the methods outlined proved to be very difficult, and sometimes extremely subjective, particularly with regard to the identification of the SL. Although these were readily and "easily" identifiable in the surgical neck of the humerus, a similar outcome was not achievable for the remaining sites. What was described as "pitting or a furrow in the cortex" of the bones, appeared multi variable in shape according to the different entheses analysed (Figure 9). Furthermore, this type of lesion was found to be absent in several anatomical sites observed, although the other category – RM – was not. Additionally, all sites affected with SL consistently exhibited RM, whilst RM affected sites did not necessarily display SL. Therefore, and as a conservative approach, SL were incorporated with RM scores in the final MSM analysis: that is, only RM scores were used in the MSM analysis.

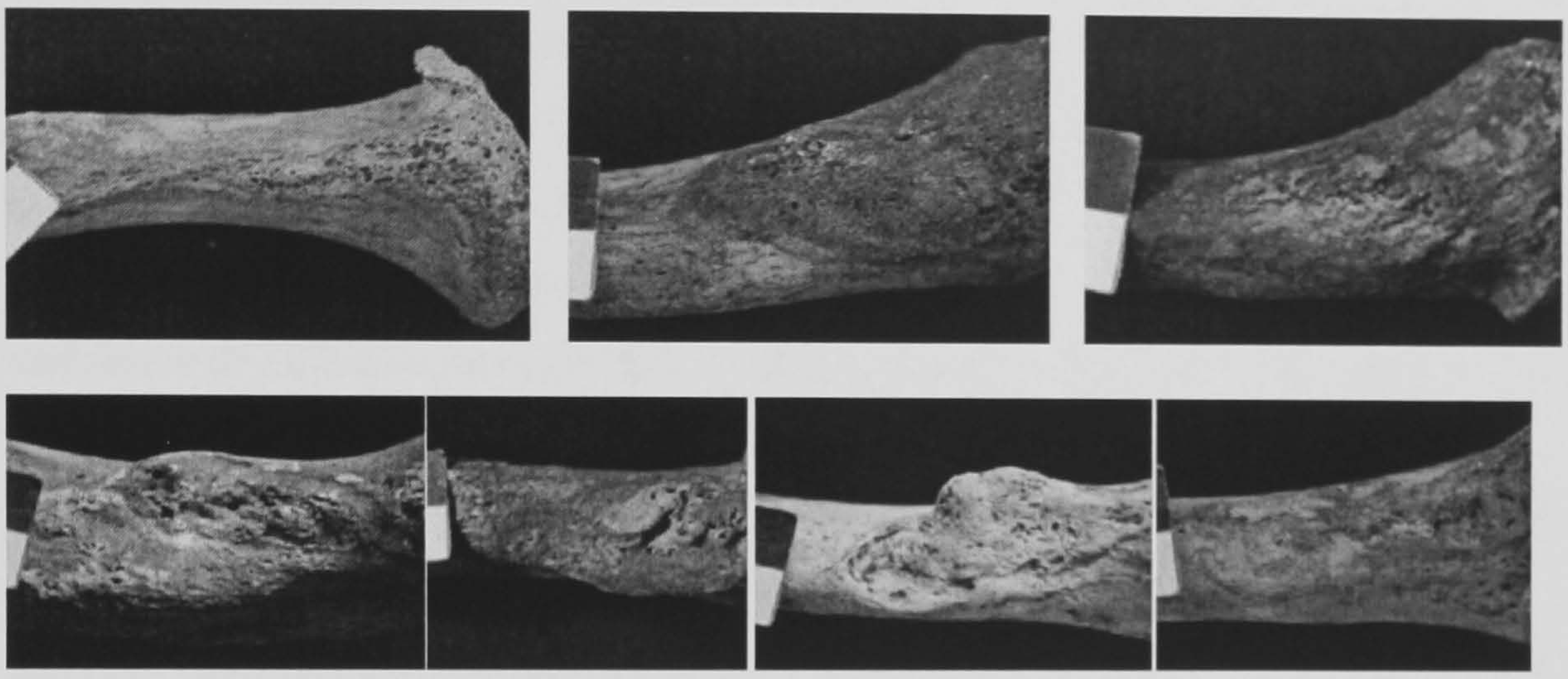

Figure 9 - Examples of the SL variability observed in the entheses of the costoclavicular ligament. The changes observed are representative of fine pitting as well as furrow/channels. All changes are associated with roughness at the site, although in some cases (examples at the top), the roughness is barely noticeable.

A second method was used to assess MSM. The second method was proposed by Crubezy and Morlock (*in* Crubezy, 1988). It is a very straightforward and simple, since it does not account for the wide expression and variability of modifications that can be observed in the method proposed by Hawkey and Merbs (1998), as SL and OE are not considered. The method provide four grades of classification for the changes observed (Table 4), stipulating a quantifiable value of 0 to >4mm length for exostoses/enthesophytes, contrary to the merely descriptive approach of Hawkey and Merbs (1995) method.

Table 4 –Categories used to score lesions found in musculoskeletal insertions sites according to the methodology of Crubezy (1988).

Grade 0	Absence of lesion
Grade 1	Minimal exostosis (< 1mm) or deformation of the site
Grade 2	Clear exostosis (between 1 and 4 mm)
Grade 3	Exuberant exostosis (> 4mm)

The initial intent in applying these two different methods was to allow for further population-comparison, particular with regard to Portuguese archaeological populations. Many of the MSM research done in Portugal (specifically in the Department of Anthropology of Coimbra University), in the past decade, used the cited method of Crubézy (1988). Almost all of these are unpublished undergraduate and master's theses[27]. For the current research, only one will be considered for comparison, a paper published by Cunha and Umbelino, in 1995. The focus on the research was to record and analyse test enthesopathic lesions in individuals with known occupations. Their major conclusion was that "...[their] findings seem to support that the role of occupational stress as a factor in enthesopathies is far from unequivocal" (Cunha and Umbelino, 1995: 66).

The correlation between the data recorded with both methods was very high. The values obtained with the statistical test (Kendall's tau-b) varied between $r=0.957$ and $r=0.999$, the level of statistical significant was always >0.001. These results proved that in these cases to use either method of recording would produce the same values. Ultimately, the method employed by Hawkey and Merbs (1998) was selected as it was more recent, and recently published papers addressing MSM favour this method (Groves, 2006; Weiss, 2007). The objective of future comparison with Portuguese archaeological populations was proved viable, as the methods revealed to be highly correlated.

Further to the analysis of MSM, a variable comprising only the more severe cases of lesions (grades 2 to 3) was created – DMSM. These results were further compared to the MSM variables to test if the statistical differences found varied. The objective of this exercise was to determine if lesions coded grade 1 had a major impact on the overall assessment of MSM. The justification was that, similarly to what had happened in the recording of marginal lipping, the lesser degrees of MSM were extremely subjective when recorded. If their impact on the sample was not of major relevance, these findings could be used to justify the use of only moderate to severe MSM lesions in bioarchaeological analysis.

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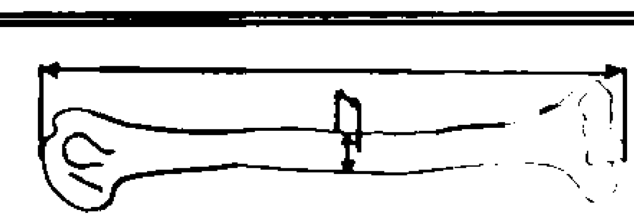
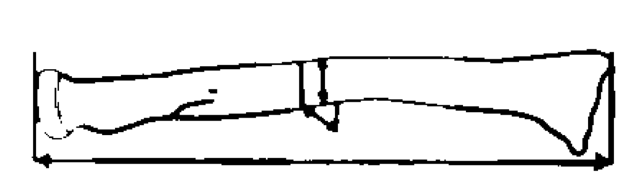
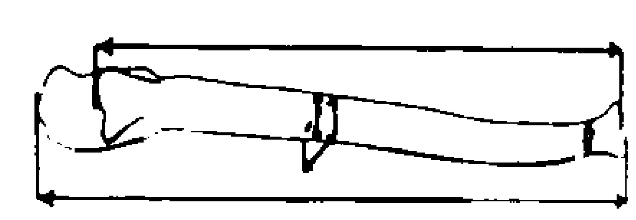
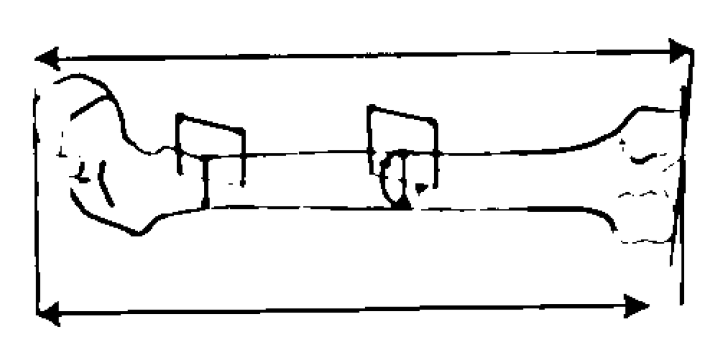
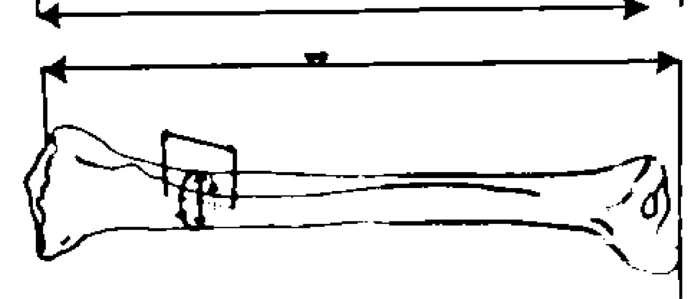
[27] For detailed information consult the online catalogue of the Department at: http://webopac.sib.uc.pt/search*por

4.1.3 External diaphyseal measurements (DEM)

4.1.3.1 Data collection

Long bone measurements were taken using either a sliding calliper (for antero-posterior, and medio-lateral diameters), an osteometrical board (to measure maximum length and physiological length), and a measuring tape (for the perimeters). Measurements were taken for both left and right bones. The schematic and description of the measurements taken can be observed in Table 5. Measurements were performed according to the descriptions provided in Buisktra and Ubelaker (1994), and Olivier and Demoulin (1990). These measurements were used to determine several postcranial indices.

Table 5 – Description and schematic of measurements used in the calculation of the postcranial indices.

Bone	Measurement	
Humerus	Maximum length Least circumference of the shaft Maximum and minimum diameter of the midshaft	
Radius	Physiological length Least circumference of the shaft Maximum and minimum diameter of the midshaft	
Ulna	Physiological length Least circumference of the shaft Maximum and minimum diameter of the midshaft	
Femur	Physiological length Anterior-posterior and mediolateral diameter of the midshaft Subtrochanteric anterior-posterior and mediolateral diameter	
Tibia	Maximum length Least circumference of the shaft Anterior-posterior and mediolateral diameter at the level of the nutrient foramen	

4.1.3.2 Methods of data analysis

The formulae used to calculate the indices are shown in Table 6. A total of three indices were calculated based on the EDM of the long bones. The indices were calculated according to the methods described by several authors (Bass, 1995;

Krogman and Yasar Iscan, 1986; Olivier and Demoulin, 1990). Preference was given to the latter authors, as their formulae has been consistently used by researchers in Portugal. Once more, the objective was to provide data for future comparisons with Portuguese archaeological populations. Indices were calculated separately for right and left side bones. For consistency, all individual indices were calculated in the same way, with some exceptions such as the platymeric and platycnemic indices of the femurs and tibiae. Once more, this was done to offer consistency to the results, and to allow future comparisons[28].

Table 6–Summarised equations of the indices calculated.

Index	Abbreviation	Bone	Summarised equation of indices
Robusticity	RI	Humerus	Least circumference of shaft *100/maximum length
		Radius	Least circumference of shaft *100/physiological length
		Ulna	Least circumference of shaft *100/physiological length
		Femur	Least circumference of shaft *100/physiological length
		Tibia	Least circumference of shaft *100/maximum length
Platymeric	PI	Femur	Subtrochanteric anterior-posterior diameter*100/ subtrochanteric mediolateral diameter
Platycnemic		Tibia	Mediolateral diameter at the level of the nutrient foramen*100/anterior-posterior nutrient diameter
Diaphyseal	DI	Humerus	Minimum diameter at the midshaft*100/maximum diameter at the midshaft
		Radius	Minimum diameter at the midshaft*100/maximum diameter at the midshaft
		Ulna	Minimum diameter at the midshaft*100/maximum diameter at the midshaft
		Femur	Anterior-posterior diameter at the midshaft*100/mediolateral diameter at the midshaft

4.1.4 Osteological analysis: other MOS observed (O.MOS)

4.1.4.1 Assessment of traumatic lesions

Only long bones were observed with regard to the presence of trauma representing either a complete or the partial break of bone continuity, or dislocation (Figure 10), which corresponds to the disruption of the normal relationship between the bony components of a joint, and the associated cartilage (Ortner, 2003).

[28] In bioarchaeology and forensic anthropology there are references to other methods of calculating the indices here referred to (Larsen, 1997; Pearson, 2000; Ruff, 2000; Wescott, 2001).

Figure 10 – Cases of bilateral dislocation of the shoulder joints, both scapulae (glenoid cavities) and humeri present severe degenerative changes: marginal lipping, porosity and eburnation were detected(skeleton #43 from the CISC: male barber, 42 years old at death).

When detected, fractures were recorded according to site affected. Long bone shafts were divided into proximal, middle, and distal thirds. The presence of a fracture, the type, and the results of healing were also documented. Evidence such as (1) visible callus formation, (2) angular deformity of bone, (3) nonunion of healed bone, (4) breaks showing indication of woven bone formation, indicating a recent fracture, were taken into consideration (Figure 11). The presences of other lesions, such as degenerative changes, or periosteal reaction as a probable result of the fracture were also considered (Figure 12), as these changes can appear as complications of the trauma.

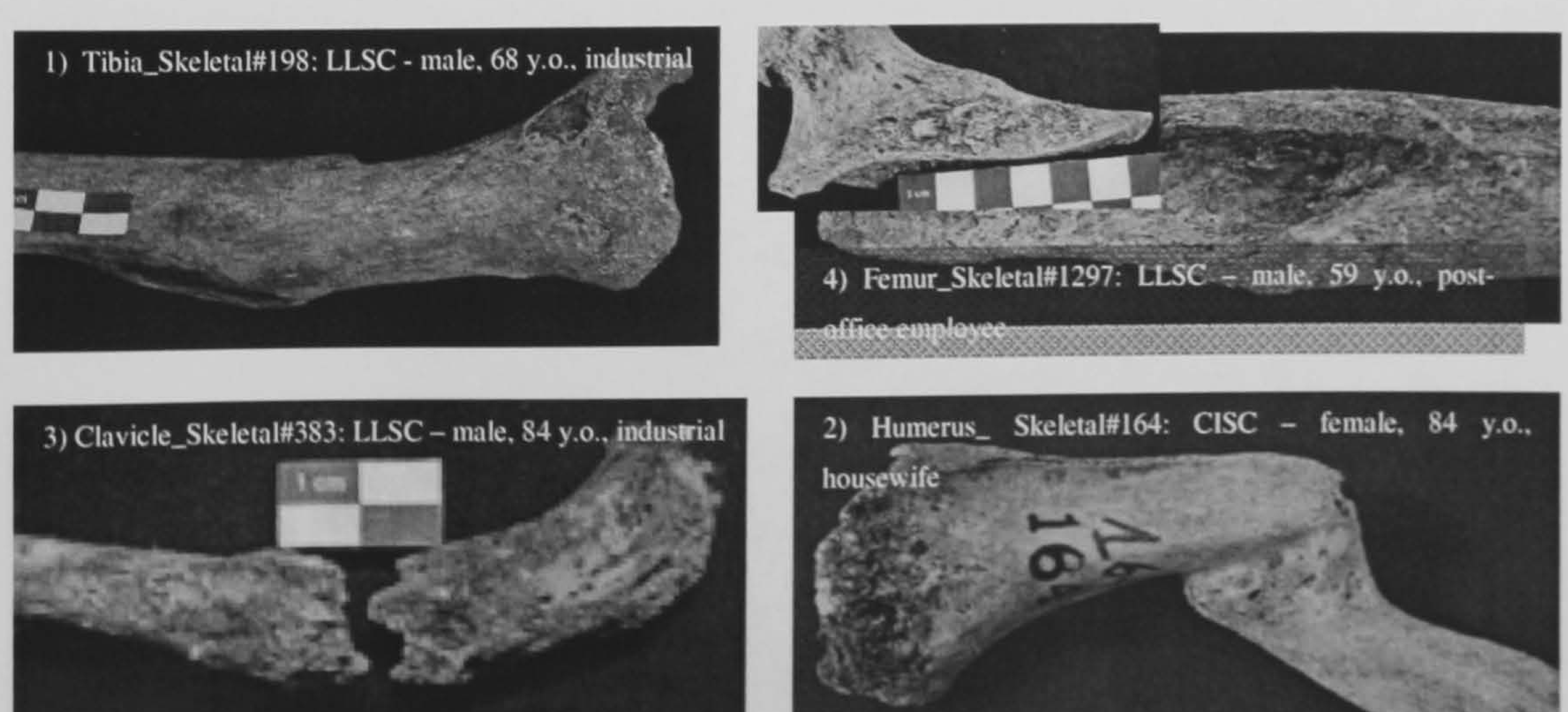


Figure 11 – Examples of traumatic lesions observed.

Figure 12 – On the left: a case of secondary OA, most probably the result of trauma (skeletal#1044: LLSC – female, 70 y.o., housewife). On the right: a case of poor healing of the facture in the femoral neck, with an exacerbated proliferation of new bone (skeletal#1040: LLSC – female, 79 y.o., housewife).

4.1.4.2 Assessment of periosteal reaction on the tibiae and fibulae

The presence of non-specific periosteal reaction in the tibiae and fibulae was recorded whenever present, in both left and right bones. It was described with reference to its location on the surface of the bone: lateral, medial or posterior surface, as well as proximal, medial or distal extremity. Only severe and/or moderate non-specific periosteal reaction were considered (Figure 13) (Larsen, 1997; Ortner, 2003; Roberts and Manchester, 2005). Cases of periosteal reaction associated with other conditions, such as trauma, osteomyelitis or cases of probable specific periosteal reaction associated with tuberculosis or leprosy were not considered (Matos, 2003; Matos and Santos, 2006; Sandell and Aigner, 2001; Santos and Roberts, 2006). In these cases the periosteal reaction could have been part of the reaction to the trauma, or related to other specific infections. For that reason, cases where trauma or specific infections were associated with the periosteal reaction were excluded from the present analysis.

Figure 13 – Examples of periosteal reaction observed in the tibiae.

4.1.4.3 Assessment of Schmorl's nodes

Schmorl's nodes were considered present in an individual whenever present in any vertebrae observed. All vertebrae were considered, and both body surfaces were inspected. When present in either body surface the lesion was classified into a four grade system, from absent to very severe, accordingly to the method presented by Capasso *et al.* (1999). Vertebrae with damaged bodies, or whose surfaces presented modifications related to other pathological conditions, such as extensive osteophytes, or other degenerative processes affecting the vertebral body, were considered missing values (Figure 14). The non recovery of any vertebra was also recorded as a missing value.

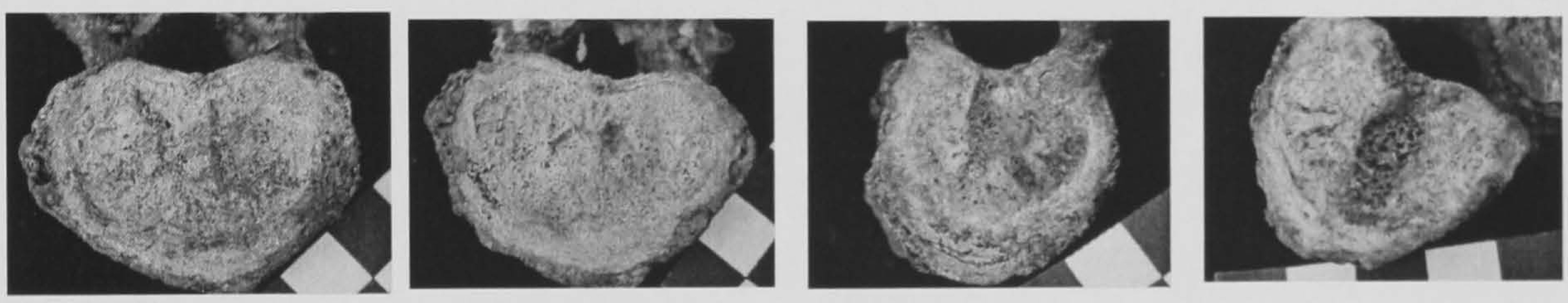


Figure 14 – Examples of schmorl's nodes observed in the vertebrae. From minor, to major expressions of the lesion.

4.1.4.4 Assessment of spondylolysis

Spondylolysis was considered present in an individual when any vertebrae observed was affected by the condition (Figure 15). All vertebrae were examined, althought this condition is mainly associated with the 4th and 5th lumbar vertebrae (Ortner, 2003). Damaged vertebrae and vertebrae with pathological or morphological alterations were regarded as missing values. Absent vertebrae were also considered missing values.

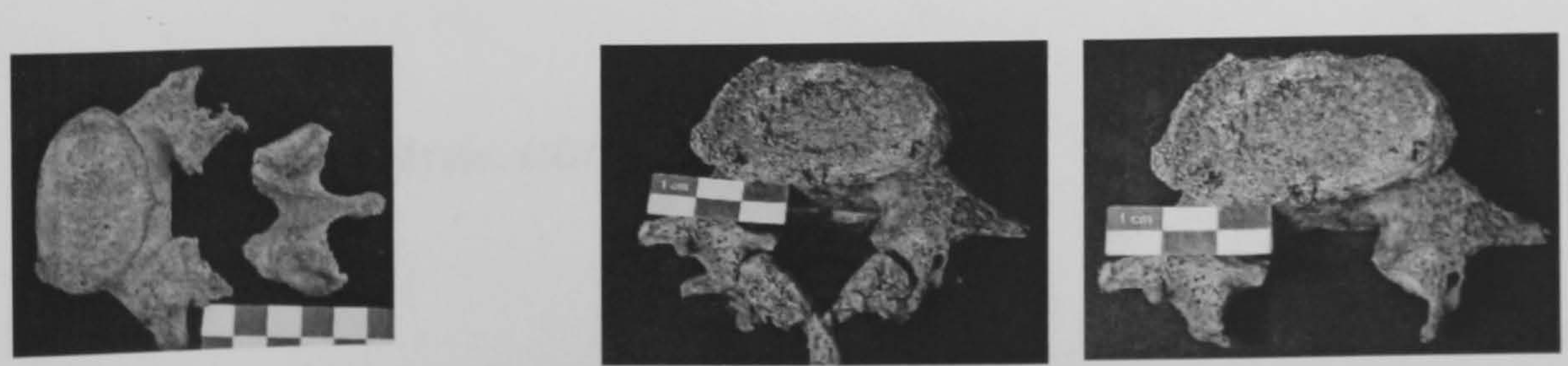


Figure 15 – Examples of cases of spondylolysis found. Left case: 5th lumbar vertebra (27). Right case: 4th and 5th lumbar vertebrae of (1287)

In the final evaluation of the O.MOS conditions only cases as present and absent were tested, and used in the current research. O.MOS were analysed per individual, and according to skeletal and sex sub-samples, age and occupational groups. Discussion of their presence will be detailed whenever found appropriate particularly when discussing the results on Chapter 7.

4.2 Methods II: statistical analysis

The current section reports the statistical methods used in descriptive and inferential statistics. The analyses were performed in two phases. In the first phase the original data was examined for each individual changes observed (DBC and MSM). In the second phase the original variables of DBC and MSM were grouped. Several new variables were created and analysed in conjunction with the postcranial indices, and with a brief reference to the O.MOS also under study.

The statistical tests performed varied accordingly to the variables. Most of the original variables recorded were either categorical or ordinal, with the few exceptions of numerical data, such as age at death and postcranial indices. The majority of the analysis aimed at sub-sample comparisons of the skeletal collections, sexes and occupational groups. Bilateral asymmetry differences were also tested in all steps of the analyses. All data were recorded into Microsoft® Office Excel, and later transferred to SPSS 14.0 for Windows, where the statistical analyses were undertaken.

4.2.1 Statistical analysis: DBC and MSM variables

This section addresses the statistical analysis template used to describe and assess differences, or associations, between the original variables recorded. These variables corresponded to the two major groups of degenerative changes observed: DBC and MSM. The DBC variables tested were marginal lipping, porosity, osteophytes and eburnation. The MSM variable tested was the presence of RM (robusticity marker/enthesopathy). All these variables were primarily recorded as ordinal: bony changes were coded according to minor, or lesser degrees of expression of the lesions. For each ordinal variable an equivalent dichotomous variable was created, expressing only the presence or absence of lesions. Details of the creation of each dichotomous variable, per bony change, are reported in the appropriate section. In the section of DBC analysis there is a sub-section of results concerning the testing of osteoarthritis (OA) in this sample. OA was recorded as dichotomous variable (Present/Absent).

The statistical template comprised of the following: summary and descriptive statistics of the variables were reported whenever possible. They included the frequencies and percentages of the different variables observed, as well as descriptive statistics with mean, standard deviation and maximum and minimum values observed. This latter statistical analysis was only used for the scale and ordinal variables. Scale variables were also tested for normal distribution using the Shapiro-Wilk statistical test. When the "normal distribution" assumption was not meet, the variables were transformed so that a normal distribution could be achieved, and parametric tests could be used. This was done using a base 10 logarithm transformation (Field, 2005). Whenever the transformation did not correct the data, non-parametric tests were used in the analysis.

To test the associations between categorical and dichotomous variables the Pearson's chi-square statistical test was used. However, the Pearson's chi-square statistical test results were always compared with those provided by the Fisher's exact test due to the uneven sample distribution of the data. In some cases the presence of lesions represented a mere 10% or less of the sample (see examples in Chapter 6: section 6.1.1). In these situations statistically significant results in 2x2 tables, for example of an association between osteophytes and sex, needed a clearer and more conservative and exact inference hence the use of the Fisher's Exact Test, which is regarded as a better alternative in this context of data analysis (Field, 2005; Field and Hole, 2003; Upton, 1992; Yates, 1984). Consequently, when the results of both tests were in disagreement, preference was given to the Fisher's Exact Test results, in deference to the most commonly used chi-square. The Cramer's V symmetric measure was also reported when a chi-square statistical test result was significant. This was done to measure the strength of association found. As in many cases, although a significant association is found, its strength may be weak and sometimes negligible.

The Independent t-test and the Mann-Whitney tests were used to compare two independent conditions. The paired t-test and Wilcoxon Signed-rank test procedures were used for pairwise comparisons. Pearson´s, Spearman's and Kendall's tau_b tests were used to test correlations between variables. The latter two tests were used whenever the normality of the variables was not assumed, or whenever a sample was small and possessed a large number of tied ranks (Field, 2005). The Kruskal-Wallis and Jonckheere_Terpstra tests were utilized to assess differences between several independent groups (for instance differences between degrees of DBC and the age at death of the individuals). The latter was used to test for an ordered pattern between the different groups of lesion, as it is considered more powerful than the Kruskal-Wallis when the populations are at an ordinal level of measurement (Field, 2005).

The Logistic Regression procedure was specifically carried out to explore the categorical outcome of the presence or absent of OA within a framework that permitted the simultaneous consideration of the effects of age and sex (Baker and Pearson, 2006; Menard, 2002; Pampel, 2000; Peng *et al.*, 2002; Peng and So, 2002). This was essential because, as it will be discussed in Chapter 5 (section 5.2.2), there is a strong sex-specific bias in the present sample due to the considerable higher number of older women. The effectiveness of the models generated by the logistic regression procedure were evaluated taking into consideration the overall model evaluation, the Hosmer & Lemeshow goodness-of-fit test (H-L), the statistical significance of the individual predictors and the overall success of classification of the model (Field, 2005). These considerations are valid for all Logistic Regression analysis.

4.2.2 Statistical analysis: Grouped_Variables

The statistical analysis performed on the grouped variables referred to as Grouped_Variables, followed the template of the analysis performed for the BDC and MSM variables. Some additional tests were performed to assess other variables associations, not explored in the first stages of the statistical analysis such as occupational group comparisons.

A major aim throughout this second part of the analysis was to guarantee that both age and sex were controlled for, whilst testing for differences between occupational groups. This was done using the analysis of covariance (ANCOVA). So that this parametric test could be used, despite the non-normal distribution of the variables, a Rank Transformation to the variables was performed. This technique implied the substitution of the data by their ranks, and the utilization of the normal parametric tests to the ranked data. This transformation has been proven to be a powerful and robust nonparametric alternative in cases were non-normal distribution of the data is known (Conover and Iman, 1981a, 1981b; Conover and Iman, 1982; Finch, 2005; Headrick and Rotou, 2001; Mansouri *et al.*, 2004; Quade, 1967; Thompson, 1991; Zwick, 1985). The data were ranked from the smallest observation to the largest, with average ranks being assigned in case of ties. ANCOVA analysis was then used both on the raw data, as well as on the ranked data. When a statistical significance was obtained for both raw and ranked data, preference was given to the results obtained with the raw data. This procedure was based on the assumption that the violation of normality had a minor influence in the outcome of the test since both raw and ranked data exhibited the same results. When the test results differed, rank data results were presented, since in these cases the violation of normality appeared to have a bigger impact on the data. Whenever the ANCOVA test results were significant within occupational groups post hoc tests, using the estimated mean results of the ANCOVA test, were undertaken.

Additional testing on several variables, or variable groups, was conducted whilst discussing the results. This was done to test some of the hypothesis addressed in the discussion section of the results chapters (Chapters 6 and 7). Whenever this situation happen a detailed justification, as well as description of the tests employed was provided.

As a general practice a two-tailed significant test was considered in all statistical tests used. One-tailed test results were only used for the Jonckheere_Terpstra statistical test since it presumes that the groups tested are ordered in a specific, a priori, predicted sequence: from minor to major lesion. All statistical procedures were carried out using the statistical package SPSS®, version 14.0.

4.3 Inter and intra-observer error measurement

This section concerns inter and intra-observer error measurement. Data for intra-observer error testing was collected 4 months after the original observation of the skeletal remains. It was performed on 80 individuals randomly selected from the LLSC and CISC (40 individuals from each collection). Data on inter-observer error measurement was also collected 4 months after the original bone observation. The researcher who duplicated the data collection was an experienced bioarchaeologist, with a minimum of three years of practice in palaeopathological analysis. The re-analysis was performed on 40 skeletons, randomly selected from the CISC. A similar analysis was not conducted on the LLSC due to human resources unavailability. The statistical test used to test inter- and intra-observer error variation was the Wilcoxon-Signed ranked test.

Data collection was only performed for DBC and MSM, and only on the left side bones. The sites selected for DBC observation were: the glenoid cavity of the scapula, proximal and distal articular surfaces of the humerus, radius, ulna, femur and tibia, the *acetabulum* and the articular surface of the patella. Degrees of marginal lipping, porosity, osteophytes on the articular surface and eburnation were examined. MSM degrees were recorded on several entheses. They are listed in Table 7.

Bone	Enthesis
Humerus	Surgical neck
	Deltoid tuberosity
	Lateral epicondyle
	Medial epicondyle
Radius	Radial tuberosity
	Interosseous border - Pronator teres insertion
Ulna	Olecranon
	Ulna tuberosity
Coxal	*Ischium* tuberosity
	Iliac crest
Femur	Greater trochanter
	Gluteal tuberosity
	Linea aspera
	Medial supracondylar line
Tibia	Anterior tuberosity
	Soleal line
	Fibular notch
Calcaneus	Posterior surface of calcaneus
	Plantar surface
Patella	Base of anterior surface

Table 7 – List of entheses examined for inter-observer error measurement.

4.3.1 Inter and intra-observer error results

According to the Wilcoxon test, no statistical significant differences were found between intra ($p \geq 0.125$) and inter-observations ($p \geq 0.070$) for the DBC, as well as for the MSM (both p-values for intra and inter-observation were superior or equal to 0.125). There was only one case of marginal non-significance ($p \geq 0.070$) in the DBC. It was observed for marginal lipping on the proximal epiphysis of the femur. In this case, the second researcher recorded fewer cases with lesions. All cases disregarded by the second observer, were coded as "barely marginal lipping" by the author.

The analyses showed that in intra-observer comparisons, there was an increase of cases in the second observation performed. All cases were related to the lesser degrees of lesions, particularly for marginal lipping. These lesions were already reported as being highly subjective, as some of the changes observed could mask bone morphological variation. One conclusion that can be drawn from these results is that, with the experience acquired during the macroscopic observation of the skeletons, the author was better able to determine morphological variations from what could be considered as pathological onset. The differences found between observers (inter) also revealed that the discrepancies found were limited to the early stages of degenerative changes.

The conclusions are mainly that: firstly, no statistical significant differences were found between inter and intra-observations; secondly, the majority of cases were coded identically, for both DBC as well as MSM; thirdly, when present, differences were consistently found in the cases were minimal changes could be observed. It would have been very interesting to test observations done by researchers with different academic backgrounds that is, researchers that follow different schools of theoretical/methodological thought, such as French, American or British. This would have enabled to pinpointing theoretical and methodological issues that need to be addressed in bioarchaeology. For instance, maybe it is necessary not only to standardize the recording, analytic and interpretative protocols, but also the *curriculum* of the discipline.

Chapter 5: The sample under study: chronological, historical and socio-economic contextualization within the late 19th and early 20th Portuguese century

This chapter addresses the sample selected for this doctoral research. The chapter is divided into three major sections which will briefly introduce the identified skeletal collections history, followed by the description of the sample selected for the research. The first section describes the Identified Skeletal Collections, and their overall historical context. The description of the collections' history is an excellent introduction to the justification of the samples selected. The second section is dedicated to the material selected for the current research. Six major points will be presented and discussed. Firstly, the parameters by which the individuals used for the research were selected are described. Secondly, the demographic profile of the sample will be presented. The demographic profile will be contextualized within the Portuguese historical period of 1800 to 1965. Thirdly, the sample will be analysed accordingly to the birthplace of the individuals. This data will be discussed within the context of Portuguese population migratory movements. The relevance of the population migratory movements will also be framed within the Portuguese social and economical context. Fourth, the causes of death of the individuals from the sample will be presented and, once more, discussed within the late 19th and early 20th Portuguese population. Fifth, the sample occupational profile will be presented. An overview of the Portuguese population occupation will also be provided. Finally, a summary of the major aspects of the sample will be given.

The final section of this chapter discusses the role of women and men in late 19th and early 20th Portuguese society. This information provided complementary information concerning the historical, social and economical dada discussed in the previous sections. It will also introduce new data concerning the sexual division of labour of the Portuguese society.

The importance of the historical, social and economical data provided for the late 19th and early 20th Portuguese population is essential to the discussion of gender, and gender-related occupational differences addressed within this thesis. The historical, social and economical overview is necessary to understand gender behaviour in the late 19th and early 20th Portuguese society. It will also provide the necessary background information to discuss markers of occupational stress within the gender context.

5.1 Brief history of the Identified Skeletal Collections

The skeletal samples studied were selected from two Portuguese identified collections, dated from the late 19th to early 20th centuries. One is known as the Coimbra Identified Skeletal Collection (CISC), and the other as the Luis Lopes Skeletal Collection (LLSC). Emphasis will be given to the Coimbra Identified Skeletal Collection (CISC) description, as the detailed analysis of the individuals that compose this collection is yet to be published, whereas the LLSC is already available (Cardoso, 2006).

The collections' history dates back to the 19th century although, in the case of the Lisbon collection, it is necessary to state that the skeletal material currently curated in the Museu Bocage, represents a "new" collection, and has little rapport to the former identified collection gathered by Dr. Francisco Ferraz de Macedo (1844-1907) (Cardoso, 2005, 2006). In 1907, Ferraz de Macedo offered the Museum Bocage a collection of one thousand crania and two hundred skeletons, All these materials were collected during late 19th century, and possessed documented biography (Matos, 2003). Unfortunately, this collection was completely destroyed by a fire that damaged the museum in 1978 (Figure 16). From the original collection only a small number of skulls, as well as documents, were recovered (Cardoso, 2005, 2006; Matos, 2003). A new collection of human skeletal remains was assembled from 1980 onwards by Luis Lopes. The majority of skeletons that now comprise the collection were gathered between the late 1980s and 1991 (Cardoso, 2005).

Figure 16– Photo taken of the Museum of National History after the fire in 1978. Photo by Francisco Reiner (26-11-2004), the original title reads: What was left of the fire of 1978 (*O que sobrou do incêndio de 1978*).
http://www.triplov.com/politecnica/fotos_museu_bocage/pages/a_incendio.htm

During the late 19th century the international interest in the study of human origins, evolution and behaviour was felt in Portugal, specifically in Lisbon, Coimbra, and Porto (Oporto); an interest seen in other European capitals. The histories of the skeletal collections being assembled during that period were intrinsically related to the history of teaching anthropology and medicine in Portugal. The discovery during the late 19th century of Portuguese Mesolithic sites, namely the Muge Shell Middens, consolidated the importance of anthropology as an academic discipline, and specifically the teaching of human evolution (Corrêa, 1919; Cortailhac, 1886; Costa, 1865: these are some of the articles published at the time). Through them, physical anthropology earned its place among the main sciences taught in universities and, in 1880, Lisbon's Congress of the French Anthropological Society (Société d'Anthropologie de Paris) took place, with the subsequent creation of the Portuguese Anthropological Society by Bernardino Machado (1851-1944) (Areia and Rocha, 1985). These events proved to be landmarks in the history of anthropology in Portugal.

The skeletons that constitute both the LLSC and CISC were retrieved from the cemeteries of the respective cities, with permission of their City Councils. It was, and is, a common practice that after a legal period of five years, the City Council is allowed to remove human remains from their primary grave and relocate them in a secondary grave. This act must be publicly advertised, so that relatives can reclaim the remains. The remains not subject to any claim are considered "abandoned" and are relocated into communal secondary graves (Câmara-Coimbra, 1998). The collections, therefore, derive from unclaimed skeletons that if not claimed by the museum, would have been reburied in communal graves (Cardoso, 2005; Rocha, 1995). It would be interesting to assess the proportion of unclaimed/claimed individuals from the time period of the collections' formation, and to see if this proportion varied over the timeframe of the sample under analysis. Ultimately, if the proportion varied over the years, it would be interesting to correlate these findings with the historical, social and economic contexts and determine which variables had biggest impact.

Biographical data is available for the individuals from both collections, although in the case of the LLSC the gathering of information is still an ongoing process. The data includes information such as age at death, cause of death, place of death, as well as the address of the individual at time of death. Contrary to the LLSC, the CISC does not give the address of the individuals, although it sometimes mentions the place of death as an address, and not the hospital or hospice (Santos, 1999)[29]. Therefore, this variable can be used as a proxy for the address of the individual. Other information available provides the place of birth[30], marital status, occupation,

[29] Most of the deaths took place mainly in the University Hospital of Coimbra (51.7%), followed by deaths occurring, presumably, in the homes of the deceased (46.3%). Only a small percentage of the individuals died in "uncommon" places (2%) such as in prison, in the mortuary (as written in the record book) or in asylums. The fact that many individuals died in hospital allowed the recovery of additional data from the University Archives. Other data were also recovered from the archives of the Coimbra Forensic Institute. Detailed research was undertaken by Ana Luísa Santos (1999) with significant results. These records provided not only additional personal data, for example description of the physical appearance of the individuals, but also information regarding personal medical records such as therapeutic practices, type of treatment according to disease, time of admission, as well as diet provided by the hospital for the patients. These findings are indeed an unquestionable contribution to the history of the medicine practiced in Portugal, particularly in Coimbra's hospitals (Santos, 1999, 2000).

[30] The reference to the birthplace of the individuals (*Naturalidade*) is very detailed. The birthplace of the individuals is listed according to *freguesia* (civil parishes), *concelho* (municipality) and finally *distrito* (district). They all refer to different administrative divisions (from the smallest to the largest) used to map Portuguese territory. In this case, Portugal is divided into *Distritos*, which are divided into *Concelhos*, which are then divided into *Freguesias*. These data are very important, especially when one is trying to understand population dynamics, and their relationship to population movements.

as well as additional administrative information from the cemetery. The CISC biographical data were compiled into what was/is known as *The Record Book* (Santos, 1999, 2000), a 505 page book with each page assigned to a skeleton, probably according to the order of their entry into the Museum. The skeletons are numbered from 1 to 504, with the exception of the skeleton labelled 100A. The information concerning the LLSC exists in a similar format (Cardoso, 2005).

5.1.1 Luis Lopes Skeletal Collection (LLSC)

A brief history of the collection has already been published by Hugo Cardoso (2006). The LLSC has been curated by the Museum and Zoological and Anthropological Laboratory of Lisbon University (Lisbon) since 1980, the date of its commencement, and is composed of 1,692 documented, and 75 unidentified individuals. The skeletons were collected mostly from the Lisbon cemeteries Alto de São João, Prazeres and Benfica. The collection of skeletons is still an ongoing process, and full detailed information is only available for 699 individuals. The remaining 993 skeletons represent new acquisitions to the collection, and are in the process of curation (Cardoso, 2006).

Based on the analysis of the 699 individuals, Cardoso (2006) concluded that the collection consists mostly of individuals of Portuguese nationality born between the years 1805 and 1972, and who died between the years 1880 and 1975. The age at death of the individuals of the sample ranges from birth to 98 years, with 92 sub-adults (<20 years) and 607 adults (>20 years), 330 females and 277 males. The majority of individuals died of problems related to the circulatory system (33%), followed by infectious diseases, specifically tuberculosis (15%), and finally tumours (13%). Based on the male occupations, the collection is said to represent lower to middle class individuals, with the most common male occupation being that of sales worker or services employee, such as civil servant (30%), followed by artisans and skilled professions, such as carpentry and tailoring (23%). Females were mostly reported as being *domésticas* (housewives/housekeepers), representing 85% of the total females, with a few individuals being maids, teachers or students (Cardoso, 2006).

5.1.2 Coimbra Identified Skeletal Collection (CISC)

The CISC has been curated by the Anthropological Museum of the Faculty of Science and Technology of the University of Coimbra since the early 20th century. At the present time the Anthropological Museum possesses a total of three main identified skeletal collections, as well as other impressive number of archaeological collections (Areia and Rocha, 1985; Areia *et al.*, 1990; Fernandes, 1985; Rocha, 1995)[31]. The CISC was collected by Eusébio Tamagnini (1880-1972) during the years of 1915 and 1942 (Areia *et al.*, 1990; Fernandes, 1985; Oliveira, 1997; Rocha, 1995). Although the CISC is not the only collection at the Museum, this is the most complete in terms of whole skeleton preservation, rather than just crania (see footnote 31 for details).

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[31] The identified collections were assembled both by Bernardino Machado and Eusébio Tamagnini, two proeminent men in the study and development, of physical anthropology in Portugal (Rocha, 1995). They were both directors of the Anthropological Museum, and it was under their supervision that the Museum acquired the identified skeletal collections (Oliveira, 1997; Rocha, 1995). The history of all the collections is intrinsically linked to the history of the Department of Anthropology, as well as that of the teaching of anthropology at the University of Coimbra. The three main documented skeletal collections, from the Museum of Anthropology in Coimbra, are known as the *Colecção das Escolas Médicas* (Collection of the Medical Schools), the *Colecção de Trocas Internacionais* (International Exchanges Collection) and the *Colecção de Esqueletos Identificados* (Identified Skeletal Collection) (Fernandes, 1985; Oliveira, 1997; Rocha, 1995). The osteological material collected by Bernardino Machado, between the years of 1896 and 1903, came from the Anatomical Museum of the Faculty of Medicine of Coimbra University and from the Medical Schools of Lisbon and Porto, and is known as the *Colecção das Escolas Médicas* (Collection of the Medical Schools) (Rocha, 1995). There are three sets of skeletal material with the generic designation of *Colecção Escolas Médicas*, but differentiated as *I*, *II* and *III*. All are mainly composed of crania (Fernandes, 1985; Rocha, 1995). The *Colecção Escolas Médicas I* comprises 585 identified crania (366 males and 219 females) that were acquired from the medical schools of Porto and Lisbon (Areia *et al.*, 1990; Oliveira, 1997). The *Colecção Escolas Médicas II* is composed of one skeleton and 13 juvenile crania, and the *Colecção Escolas Médicas III* is represented by 34 crania (Rocha, 1995) Eusébio Tamagnini, who followed Bernardino Machado as director of the Museum of Anthropology between 1907 and 1950, acquired the two remaining skeletal identified collections; the *Colecção de Trocas Internacionais* (International Exchanges Collection) and the *Colecção de Esqueletos Identificados* (Identified Skeletal Collection) (Oliveira, 1997; Rocha, 1995). Both collections were mostly recovered from the Conchada's Cemetery in Coimbra. The *Colecção de Trocas Internacionais* was acquired between the years of 1932 and 1942, with the main purpose of being a resource for both national and international researchers (Areia *et al.*, 1990). The collection is composed of 1075 crania and mandibles (Areia *et al.*, 1990).

The CISC presently comprises 505 complete skeletons of people born between 1826 and 1922, most of them in Portuguese territory. The analysis conducted by the present author into the CISC concluded that the majority of the skeletons were from the Conchada's Cemetery, in Coimbra (98.6%), with the remaining 1.4% being recovered from the Anatomical Museum of Coimbra University. The collection is composed of 266 males and 239 females. Non-adults, represented by individuals less than 20 years old at the time of death, represent only 6.8% of the collection. The age at death of the entire collection ranges from seven to 96 years, with the years of death ranging from 1904 and 1938. Unfortunately, there are two individuals whose age at death is unknown and impossible to calculate (subtracting the birth date from the year of death). The most common causes of death are those attributed to infectious and parasitic diseases (30.3%), followed by diseases of the circulatory system (21.6%) and respiratory system (10.4%). Tuberculosis accounts for more than half of the deaths caused by infectious and parasitic diseases.

Once more, and as seen in the LLSC, male data on occupation is very detailed, contrasting with the almost unique assignation of womens' occupations as *doméstica,* that is women were described as performing domestic-related chores. The majority of the males (n=255) were employed as waiters (*serviçais*), farmers and unqualified workers - *trabalhadores* (33.3%), followed by skilled activities such as those of barbers, carpenters, tailors and shoemakers (28.2%). Thirdly, there were male occupations related to commerce and transport (12.9%), closely followed by males engaged in liberal professions, working in the civil service or academia (12.2%). The remaining 8.2% of the individuals were engaged either in the armed forces, or were described as owners (*proprietário*) or industrialists (5.1%). As already referred, women (n=227) were mostly described as "*domésticas*" (87.7%) according to this description they would be engaged in either house-related chores, or in domestic works such as waitressing, or as domestic servants (8.8%). Five women were employed as seamstresses (2.2%) and only two had an occupation related to commerce (0.9%).

In summary, the chronological framework of the collections covers a long period of Portuguese history. More than a century if one considers both times of births and death of the individuals, although the timeframe of the CISC (1826-1938) is slightly narrower than that of the LLSC (1805-1975). This fact, allied with the biographical data provided, per individual, and the fact they represent slightly different communities, Lisbon a metropolis and Coimbra a more rural district, makes both collections unique tools for studying the Portuguese population at that time. One can use both the historical data, as well as the information provided by the skeletal material. They both complement each other and interact producing a truly multidisciplinary and holistic approach to that epoch.

5.2 Skeletal samples

The following section will describe the sample used in this research. The demographic profile of the individuals of the samples, their birthplace, causes of death and occupation will be reported. All biographical information for each individual will be complemented with historical data from the chronological context of the samples. This will place individuals into their historical, geographical and social context. This is of enormous importance for assessing questions about gender. The final section of this chapter will address male and female working contexts.

5.2.1 The selection of the samples

Skeletons were selected according to their available biographical information and state of preservation. After a first selection, based on the above parameters, skeletons were inspected for the presence of pathological conditions that could bias the study. For instance, osseous changes observed in seven individuals from the CISC, led to the exclusion of these individuals from the analysis since the modifications observed were most probably related to specific pathological conditions. The osseous changes observed consisted mainly of extensive and severe ossification of muscular insertion sites, segments of the vertebral column and of the pelvic girdle. These individuals were replaced by others that corresponded to the requirements, that is, complete biographical data and a good state of preservation. This method of selection was employed in both collections.

As noted above, the majority of the cases excluded were of individuals with a most probable diagnosis of DISH[32], which leads to the development of enthesopathies, or the ossification of muscular insertions sites. The presence of exuberant enthesopathies, associated with antero-lateral fusion of several thoracic vertebrae (with the formation of osseous bridges between the bodies), as well as fusion of the sacrum with the os coxae, were the criteria used for eliminating the above mentioned individuals (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003; Roberts and Manchester, 2005; Rogers and Waldron, 1995). However, although some skeletons possessed fused segments of the vertebral column, they did not present supplementary skeletal modification that could easily be related to any of the diseases which accompany such specific osseous changes. For that reason these individuals were maintained in the original sample selected.

5.2.2 Demographic profile

Six hundred and three skeletons were analysed: 299 skeletons from the CISC (149 males and 150 females) and 304 skeletons from the LLSC (151 males and 153 females). The sample represents individuals that were born between 1822 and 1935, and who died between 1891 and 1965 (Figure 17).

[32] DISH is a pathological condition known as diffuse idiopathic skeletal hyperostosis (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003). This condition was described in the medical literature as early as the 19th century (Ortner, 2003). In the older medical literature ankylosing hyperostosis and Forestier's disease have also been used as terms for this disease. The main feature of this disease is a tendency to produce excessive amounts of bone at joint margins and at entheses. A criterion used for diagnosis is the presence of at least four adjacent vertebrae fused; the facet joints are not usually involved and the disc space is generally maintained (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003; Rogers, 2000).

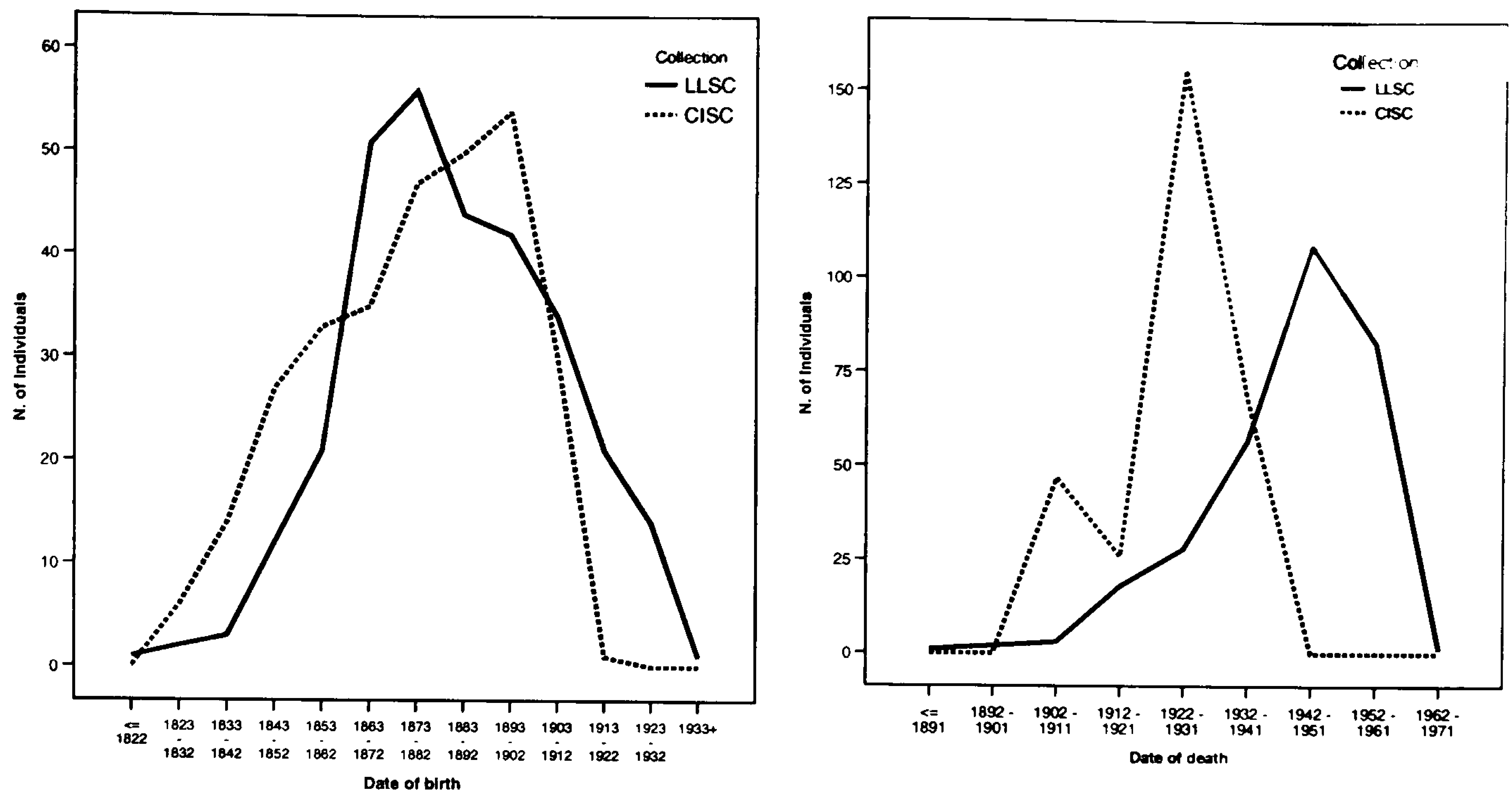


Figure 17 – Distribution of the individuals according to decades of birth and death.

The decades reflecting the years from 1863 to 1912 showed an even distribution of individuals according to birth; none of the decades assumed a predominant role. In the "death decades" 70% of individuals died between 1922 and 1951, with a recognizable death peak between 1922 and 1931. However, inferences based on these dates need to consider that the higher, or lower number of deaths (or births) may simply echo the availability of skeletons retrieved in the respective cemeteries. They should therefore, not be associated with particular events, either of international nature, national or regional. To do such, one would have to compare this information with other demographic data, such as mortality rates.

There is a slight difference, between skeletal samples and their chronological framework, particularly with regard to their time of death. The CISC individuals died between 1823 and 1936, and the LLSC individuals died between the years 1891 and 1965. Consequently, one can state that the LLSC was exposed to a wider variety of political, social and economic occurences when compared to the sample from the CISC. One could therefore question if those changes were reflected in their way of life, and consequently in their skeletons. Furthermore, it is necessary to remember that, whilst the LLSC provenance is urban (Lisbon), the CISC origin is that of a rural population. Hence, substantial differences would be expected between individuals, particularly with regard to their socioeconomic profile; once more those contrasts may be reflected in their skeletons.

The age at death of the sample ranges from 20 to 98 years. Statistical analysis showed that age was positively skewed, and not normally distributed ($p<0.001$). The majority of the individuals, or 62.2% (375/603), were $\leq$ 59 years at death. The remaining 37.8% (228/603) were between 60 and 98 years at the time of death, of which 60.5% (138/228) were women. Consequently, the mean age at death for males (49.78 years) was lower than for females (55.96 years: Table 8), and this was significantly different ($U=37064.5$, $Z=-3.921$, $p<0.001$, two-tailed significance). When comparing collections, the LLSC had a higher mean value than the CISC, and this difference was significant ($U=32439$, $Z=-6.083$, $p<0.001$, two-tailed significance). When analysing sex-related differences in the collections' sub-set, the differences between males and females were much more accentuated (see Table 8 for details); in both sub-samples the differences between males and females were statistically significant (LLSC: $U=9199$, $Z=-3.071$, $p=0.002$, two-tailed; CISC: $U=9130$, $Z=-2.736$, $p=0.007$, two-tailed significance). The data illustrate the necessity to control for age in all the analyses to be performed. Not only by collection, but also in the baseline sample, as well as sex sub-samples. This is necessary as the female age bias found could compromise the results and their interpretation, if not controlled for.

Table 8 – Descriptive statistics of age at death, per collection, sex and total sample.

	Lisbon Collection			Coimbra collection			Total		
	Female	**Male**	**Total**	**Female**	**Male**	**Total**	**Female**	**Male**	**Total**
N	153	151	304	150	149	299	303	300	603
Mean	60.40	54.55	57.49	51.43	44.95	48.20	55.96	49.78	52.88
Std. Deviation	19.47	17.08	18.53	19.55	15.95	18.11	19.99	17.19	18.89
Minimum	20	20	20	20	20	20	20	20	20
Maximum	98	88	98	95	84	95	98	88	98

Portugal: brief political history (1800 – 1965).

Between 1800 and 1974, which roughly covers the timescale of births and deaths of the individuals that compose the present sample, Portuguese political history can be divided into three major periods: the Constitutional Monarchy (1820-1910), the First Republic (1910-1933) and the Dictatorship, *Estado Novo* (1933-1974). Each era had its political singularities, but all contributed to the socio-economically underdevelopment of Portugal until the late 20th century. Indeed, certain areas of Portugal still preserve much of the "old days" atmosphere. The older women still wear the same clothes, the peasants still work the land in similar manner, and men still sit in the "tasca/taberna"[33] (Figure 18) and sleep the "sesta" during the days of summer.

Figure 18 – Men in a *taberna* in Lisbon, in 1930 (left) and 1967 (right)[34].

The political episodes reported above not only left a deep scar on the development of the country, but were particularly marked by unparalleled social disturbances. Prior

[33] Usually found in the smaller villages, and older areas of major towns. The "tascas" are a reminiscence of the old commercial shops usually divided in to two areas: in one they would sell agricultural products, and other goods not produced by the land, such as rice, butter, milk, sugar, soap, amongst other things; in the other area they would mostly sell wine, and other viticulture products such as "fire-water" (*aguardente*). Here, men would gather to drink, mostly wine produced locally, and discuss politics. Women were not welcome into this ale-centric atmosphere. These gatherings would occur especially on Sundays, the day of the Lord, the day of rest.

[34] Original description of photos and references:
Left: "Taberna" (HACML, 1930, PT/AMLSB/AF/EFC/002151);
Right: "Taberna no Campo de Santa Clara" (HACML, 1967, PT/AMLSB/AF/NUN/S01072).

to those events, Portugal had already experienced the French invasions, between 1807 and 1811, which were followed by a Liberal Revolution in 1820, marking the beginning of the Constitutional Monarchy. The Independence of Brazil, in 1822, followed by the regicide in 1910, the unstable 1st republic, and ultimately the dictatorship, summarise the unfortunate chain of political events that characterized the 19th and 20th Portuguese history. For much of the 20th century Portugal's development was slow-paced. The country would remain mostly as it had been during the 19th century, particularly in the rural areas.

The economic consequences of the political drawbacks, such as the independence of Brazil, were severe as Portugal lost one of the country's economic pillars. In the early 19th century Rio de Janeiro had become the new Portuguese Capital city, a consequence of the royal family's exile, in 1811 compounded by the follow-up migration of many rich merchants, and other high ranking officials of the civil administration. Rio de Janeiro was flourishing economically, whilst Portugal was withering (Saraiva, 2003). Having lost its main commercial asset, the country was forced to rely on its non-specialized and non-industrialized agriculture, plunging the population into economic depression. The country experienced general outbursts of civil protest, which ultimately led to the end of the monarchy, in 1908. The end of monarchy was crowned with the murder of the governing king, D. Carlos and his son, the prince D. Luís Filipe. The monarchy would linger on for only two more years, under the rule of D. Manuel II (the second son of D. Carlos), and on the 5th of October of 1910 the 1st Republic was proclaimed in Lisbon (Figure 19).

CORREIO DE PORTUGAL

Assassinio de Sua Magestade El-Rei D. Carlos e de Sua Alteza o Principe Real

Proclamação de El-Rei D. Manuel

Figure 19 – Announcement of the regicide in the newspaper *Correio de Portugal*, in 8 of February of 1908. The headline reads: "Murder of His Majesty the King D. Carlos and of his Highness the Royal Prince. The second headline reads: "Proclamation of the King D. Manuel".

Despite the political change, economic weakness persisted as well as political instability. The situation was substantially aggravated by the First World War. The political instability, particularly high during 1920 and 1926, ultimately led to a military *coup d´etat* in 1926. This represented the end of the 1st Republic, and marked the beginning of the national dictatorship later known as the *Estado Novo* (New State), headed by António de Oliveira Salazar (1889 - 1970)[35].

The *Estado Novo* internal politics aimed for a re-arrangement of the general administration and armed forces, and also sought to develop public infrastructures. Although primary sector activities such as agriculture continued to dominate the economy, between 1933 and 1952, many dynamic efforts were made to develop

[35]Unlike many of Portugal's would-be rulers of the 19th and 20th century, Salazar was a scholar, a professor of finances in the University of Coimbra. In 1932 he was nominated president of the *Conselho de Ministros* (Council of Ministers) within the new government born of the *coup d´etat*, and changed the overall government typology which had been historically dominated by the military. Henceforth, the government was composed mostly of scholars, recruited from Universities (Saraiva, 2003). The "unofficial" government nurtured by the *coup d´etat* was legalised in 1933, with the approval of a new Portuguese Constitution, and the dictatorship was proclaimed *Estado Novo* (the New State) (Baiôa *et al.*, 2003; Saraiva, 2003). The dictatorship was a fascist regime, akin to many others throughout Europe during the 20th Century. Individual freedom was limited, when existent, and strong censorship restricted the press. During the dictatorship all political and union leaders opposed to the ruling law were persecuted, and would typically end up in exile or imprisoned (Soares, 1975). During the Second World War Portugal adapted a neutral status, providing both sides of the conflict with raw materials, and as a direct result, and for the first time since the end of the 18th century, the economic situation gained a measure of stability between 1940 and 1943.

industry and stimulate the economy: roads, bridges, schools and libraries were commissioned, alongside other official buildings and infrastructures (Kay, 1970; Saraiva, 2003). Despite these industrial developments, agriculture remained rooted in the traditions of the past, and the cities developed quite independently from the countryside, resulting in a significant disparity in salary levels, as well as social and wider economic status. This social disparity drove many of the "peasant class" to leave their traditional homes and livelihoods, seeking social betterment in the cities. As a result, levels of emigration were high, particularly from the countryside.

On a global level, Salazar's ambitions were to achieve political and economic independence for Portugal within the international sphere, whilst simultaneously preserving its colonies[36], which by the mid 20th century had mostly been reduced to its African states (Baganha, 2003; Baiôa *et al.*, 2003; Saraiva, 2003). Regrettably, for Salazar, these aims proved unattainable, as from 1961 onwards Portugal faced the political challenge of many of its colonies' desire for independence. In 1961 guerrilla wars started in Angola followed by Mozambique. These would later be known as "*Guerra do Ultramar*" (the Overseas War). These conflicts, which lasted 13 years, proved to be the "Achilles heel" of *Estado Novo*, draining much of its economic and human resources (many young males were either sent to battle, or simply fled to other countries, such as France). The conflict also isolated Portugal from the international political community, and would ultimately lead to the overthrow of the dictatorship.

Salazar ruled for 36 years, from 1932 until 1968, and only stepped down due to illness. He was succeeded by Marcelo Caetano who headed the Government until 1974. This date would become known as "*A Revolução dos Cravos*" (The Carnations' Revolution) or "*O 25 de Abril de 1974*" (The 25th of April) (Figure 20 and 21).

[36] Portuguese territory during the *Estado Novo*, until 1961, comprised the mainland Portugal; the Azores and Madeira archipelagos; the overseas provinces of Angola (West Africa) and Mozambique (East Africa); the Cape Verde Islands, and the islands of São Tomé and Príncipe (off the West African coast); Macau in China; Timor in the Indonesia archipelago; and the Portuguese Indian provinces of Goa, Diu and Damão (Kay, 1970)

(http://img255.imageshack.us/img255/5620/25abril5fa.jpg).

Figure 20 – The *Revolução dos Cravos*.

The long lasting Portuguese dictatorship would end on the 24th of April of 1974, in a revolution that would become known as: A Revolução dos Cravos. The name came about as the military (Armed Forces Movement) and the population that flooded the streets, all wearing carnations in their hands, on their clothes and on their guns, as a sign of peace, of victory, and mostly as a sign of freedom.

República

As Forças Armadas tomaram o poder

OS GENERAIS SPÍNOLA E COSTA GOMES DEVEM VIR A FORMAR UMA JUNTA MILITAR

PELO POVO E PELAS SUAS LIBERDADES

PROCLAMAÇÃO DO MOVIMENTO DAS FORÇAS ARMADAS

ESTE JORNAL NÃO FOI VISADO POR QUALQUER COMISSÃO DE CENSURA

Figure 21 – The headline reads: "the Armed Forces Have Taken the Power". The smaller headline states: "for the people and its liberties".

5.2.3 Birthplace of the individuals

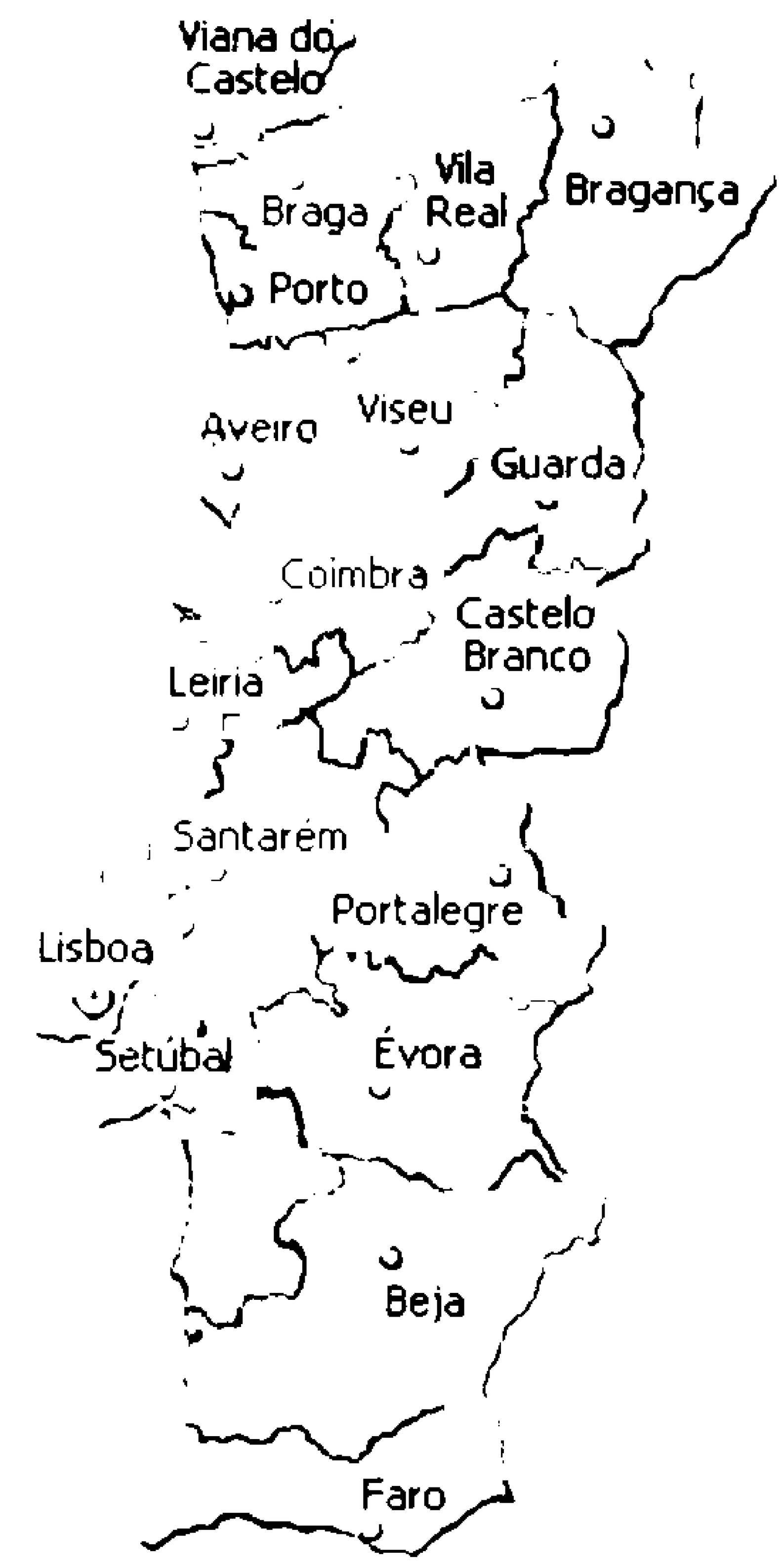
The majority of individuals studied in the samples were born on the Portuguese mainland, with some exceptions of men and women born in former Portuguese overseas colonies, such as Brazil and Africa, and individuals of Spanish nationality (Table 9). Overall, individuals from all Portuguese districts were represented in the sample (Figure 22), but the number of individuals from the cities of Coimbra (in the CISC) and Lisbon (in the LLSC) were significantly higher: CISC – 50.8%, LLSC – 44.9%. That is, samples were mainly composed of individuals born in the same district where they were buried.

Table 9 - Distribution of individuals from the samples according to district of birth. The collections' sub-sample and total sample frequency are presented.

Birth place	Aveiro	Beja	Braga	Bragança	Castelo Branco	Coimbra	Évora	Faro	Funchal	Gouveia	Guarda	Leiria	Lisboa	Portalegre	Porto	Santarém	Setúbal	Viana do Castelo	Vila Real	Viseu	Others*
Lisbon collection																					
Count	10	7	4	5	17	20	7	10	2		6	8	132	9	10	18	6	2	5	7	9
% within Collection	3.4	2.4	1.4	1.7	5.8	6.8	2.4	3.4	0.7		2.0	2.7	44.9	3.1	3.4	6.1	2.0	0.7	1.7	2.4	3.1
Coimbra collection																					
Count	10	1	6	2	7	151		1	1	1	30	22	3	6	9	10		4	5	25	3
% within Collection	3.4	0.3	2.0	0.7	2.4	50.8		0.3	0.3	0.3	10.1	7.4	1.0	2.0	3.0	3.4		1.3	1.7	8.4	1.0
Total																					
Count	20	8	10	7	24	171	7	11	3	1	36	30	135	15	19	28	6	6	10	32	12
% within Sample	3.4	1.4	1.7	1.2	4.1	28.9	1.2	1.9	0.5	0.2	6.1	5.1	22.8	2.5	3.2	4.7	1.0	1.0	1.7	5.4	2.0

*- Includes individuals born in Africa (Angola and S. Tomé), Macau and Spain.

Figure 22 - Division of the mainland Portuguese territory by district. The birthplace of the majority of individuals was either the cities of Coimbra or Lisbon (comprising 51.8% of the total sample).



The importance of the birthplace of the individuals is based on the assumption that this can be used to trace the individuals' movement since birth, that is their migration. The association of this variable with other social parameters, such as poverty levels, permits the tracing of a more reliable profile of the population under study. For instance, during the 19^{th} and mid to late 20^{th} century the poor living-conditions of the majority of the rural population promoted the exodus of people into the major urban centres of the country. Although, between 1890 and 1930, more than 90% of the population lived in their birthplace, there were a considerable number of "outsiders," that is non-district natives populating the major cities of Portugal, such as Lisbon and Coimbra. Statistical data refers to a percentage of 22.1% and 2.3% (Lisbon - Coimbra) of non-city natives in the year 1890, and 30.1% and 5.4% (Lisbon-Coimbra) in 1930. The attractiveness of the capital, Lisbon, is well expressed by the number of "outsiders," when compared to a more provincial town such as Coimbra (Rodrigues and Baptista, 1996).

At first rural Portuguese were migrating to the bigger cities, but soon started to target foreign countries, mainly Brazil, along with other South and North American countries[37] (Veiga, 2004). This migration, allied with the fact that the majority of the population lived close to bigger cities such as Lisbon and Porto, enlarged the population gap between rural and urban areas (Veiga, 2004). In some regions the number of migrating people was so high that it jeopardised the survival of the local population; workers dwindled in number and there was an ever-increasing imbalance between the sexes as most migrants were male (Arroteia, 1985; Ribeiro, 1998; Veiga, 2004).[38] The countryside was becoming deserted while the city centres struggled to cope with an ever-growing population, resulting in new challenges with regard to housing, sanitation and social infrastructures in general (Rodrigues, 1997; Rodrigues and Baptista, 1996).

As expected the majority of migrants were rural, uneducated, unemployed single males, aged 15 to 35 years (Baganha, 2003; Saraiva, 2003; Veiga, 2004). In 1901 and 1905 the percentage of illiterate emigrants was 55% and 57%, respectively, of the total number of migrants (D.G.E., 1908). This tendency was sustained throughout the 20th century as proved by statistical data (D.G.E., 1924). However, teachers, university students, merchants, sailors, soldiers, diplomats and voyagers were also contributing to the overall emigration numbers. Despite the male predominance, by the end of the 19th century women were also "on the move," firstly to the major city centres to work as servants, cleaning-ladies, dressmakers and factory-workers (Veiga, 2004), and ultimately to other countries. In 1960 women represented 46% of the workforce who left the country (I.N.E., 1961).

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[37] In 1880, 97% of people who left Portugal emigrated to Brazil (M.O.P.C.I., 1886). In 1960 South America, namely Brazil, was still the main place where Portuguese migrated (51.6%), followed by North America (33.6%), Europe (11.7%), Africa (2.5%) and Oceania (0.6%) (I.N.E., 1961). However, during the second half of the twentieth century, this tendency changed radically. In 1965, 80.2% of people were migrating to other European countries, with the principal destination being France. At this time only 8%, and interestingly most of them women, were choosing South America as their destiny (I.N.E., 1966b). Between 1933 and 1974, approximately 1.98 million Portuguese left the country heading mostly to Europe, 32% of whom did so in a clandestine manner (Baganha, 2003). Without question, the oppressive regime felt during the *Estado Novo* and the *Guerra do Ultramar* were the major factors responsible for this clandestine exodus.

[38] At the beginning of the 20th century the districts most affected with emigration were Aveiro, Porto and Viseu, all of them centred in the littoral/western-north of Portugal (Arroteia, 1985). For details on Portuguese districts see Figure 22, page 50.

Only a small proportion of the sample represents this migration behaviour (see Table 9) [39]. As discussed earlier, the majority of the individuals were born and died in the districts of the collections origin,[40] Coimbra and Lisbon, contradicting, to a certain extent, the overall description of the Portuguese population as one of "moving masses." However, the lack of a higher percentage of migrants in the collections may merely reflect the availability of individuals for collection. Consequently, the geographic composition of the collections may bear little relationship to overall populational behaviour. Therefore, an analysis with regard to birthplace of the people that lived and were buried in the Coimbra and Lisbon cemeteries would only be valid if based on parish (or other) records. Only then would it be possible to establish the exact migratory movements of the communities under study. Based on the identified skeletal collections, only a partial perspective of these and other socio-economic parameters can be achieved.

5.2.4 Causes of death

A successful attempt was made to identify almost all causes of death according to the World Health Organization's ICD-10, International Classification of Disease (W.H.O., 2007, 2003). The cause of death was available for most individuals, as part of their biographical data. However, in some cases the information was either imprecise or incomplete preventing its correct identification. Twenty two cases were also found with more than one disease as cause of death. Nevertheless, it was possible to conclude that the most common causes of death were diseases related to the circulatory system (27.9%), such as arteriosclerosis, cardiac insufficiency and syncope; followed by infectious and parasitic diseases (23.8%), particularly tuberculosis. It was interesting to find tuberculosis associated with infectious and

[39] A brief description of the history of the identified skeletal collections, as well as their demographic composition can be found in section: 5.1.

[40] As referred to earlier, Portugal is divided into *Distritos*. Each one is further compartmented into *Concelhos*, and then *Freguesias*. Consequently, to say that an individual was born in the *Distrito* of Coimbra, or Lisbon, would not necessarily refer to the city itself, as the *distrito* would include the outskirts of that city.

parasitic diseases, rather than with problems in the respiratory system. Neoplastic diseases were the third most common cause of death (10.7%), followed by diseases of the respiratory system (8.5%), such as bronchopneumonia and pneumonia, and diseases of the digestive system (8.3%), for example ulcers and intestinal obstruction (Table 10). The most common causes of death were the same by sex and in both collections (Figure 23).

Table 10 – Distribution of the individuals according to cause of death.

	International classification of disease (W.H.O.)	Collection		Sex		Total samples		
		C.I.S.C.	L.L.S.C.	Female	Male	n	%	valid %
1	Certain infectious and parasitic diseases	80	60	50	90	140	23.22	23.81
2	Neoplasm	28	35	38	25	63	10.45	10.71
3	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	3	1	2	2	4	0.66	0.68
4	Endocrine, nutritional and metabolic diseases	2	3	2	3	5	0.83	0.85
5	Disease of the nervous system	7	7	5	9	14	2.32	2.38
6	Diseases of the circulatory system	66	98	85	79	164	27.20	27.89
7	Diseases of the respiratory system	32	18	30	20	50	8.29	8.50
8	Diseases of the digestive system	26	23	29	20	49	8.13	8.33
9	Diseases of the skin and subcutaneous tissue	_	1	1	_	1	0.17	0.17
10	Diseases of the musculoskeletal system and connective tissue	_	1	_	1	1	0.17	0.17
11	Diseases of the genitourinary system	9	9	8	10	18	2.99	3.06
12	Pregnancy, childbirth and the puerperium	4	2	6	_	6	1.00	1.02
13	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	7	18	20	5	25	4.15	4.25
14	Injury, poisoning and certain other consequences of external causes	6	7	7	6	13	2.16	2.21
15	External causes of morbidity and mortality	2	4	2	4	6	1.00	1.02
16	Other causes	4	3	2	5	7	1.16	1.19
17	More than one disease (as cause of death)	14	8	8	14	22	3.65	3.74
18	Without reference/unknown	9	6	8	7	15	2.49	_

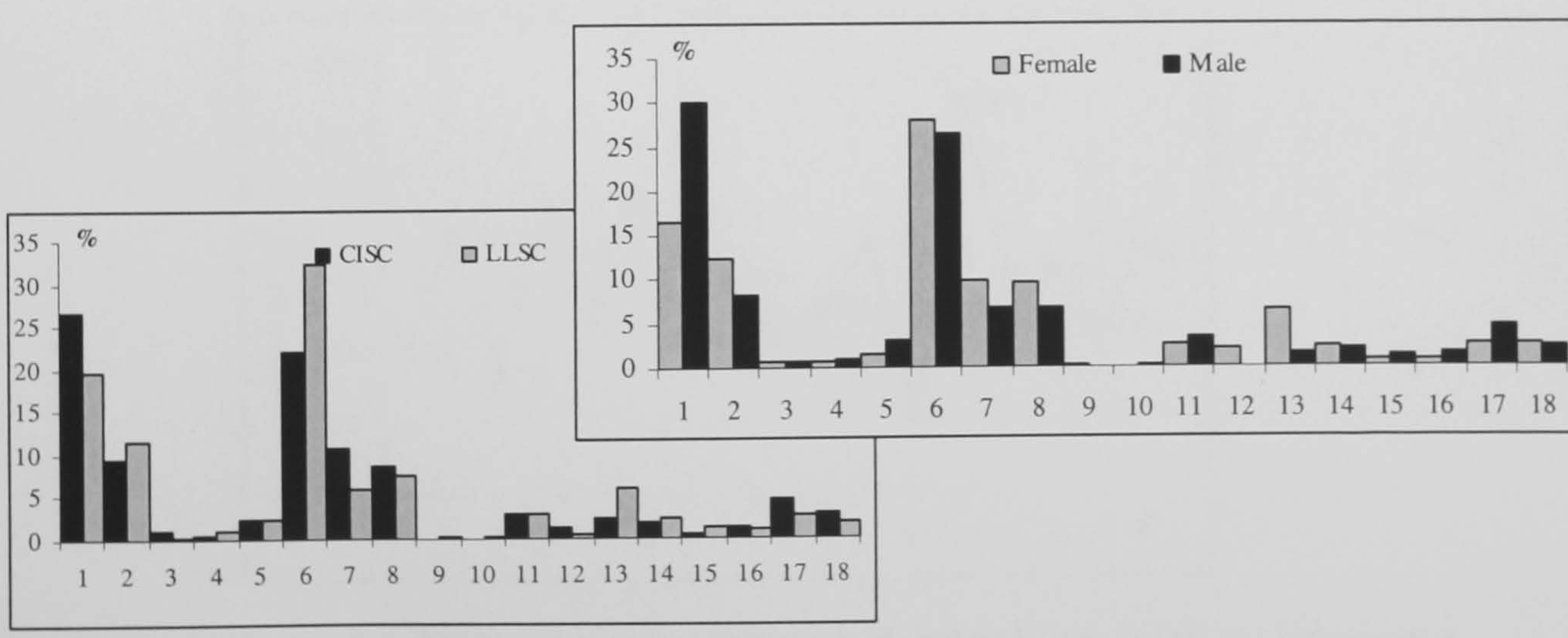

Figure 23 – Collections and sexes sub-samples distribution of the individuals according to cause of death (see Table 10 for numbers description).

According to the Kruskal-Wallis statistical test, there was a statistically significant difference between the age at death of the individuals categorised by their cause of death ($H_{(16)}=142.534$, $p<0.001$). Detailed descriptive statistics about the age at death by the WHO disease-group on the cause of death can be consulted in Table 11 and Figure 24. The younger individuals of the sample died of childbirth related problems, naturally all of them women; whereas the older individuals died of old age related illnesses such as debility and senility.

Table 11 – Descriptive statistics of age at death according to cause of death.

	International classification of disease (W.H.O.)	N	Mean	Std. Deviation	Minimum	Maximum
1	Certain infectious and parasitic diseases	140	40.29	14.979	20	80
2	Neoplasm	63	56.13	17.205	21	93
3	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	4	36.50	15.416	21	53
4	Endocrine, nutritional and metabolic diseases	5	60.20	11.925	46	76
5	Disease of the nervous system	14	47.07	22.148	21	95
6	Diseases of the circulatory system	164	60.21	17.172	23	98
7	Diseases of the respiratory system	50	57.70	17.860	20	89
8	Diseases of the digestive system	49	49.63	16.714	21	87
9	Diseases of the skin and subcutaneous tissue	1	41.00	.	.	.
10	Diseases of the musculoskeletal system and connective tissue	1	45.00	.	.	.
11	Diseases of the genitourinary system	18	54.50	14.329	25	76
12	Pregnancy, childbirth and the puerperium	6	30.50	7.232	21	39
13	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	25	74.16	16.025	21	87
14	Injury, poisoning and certain other consequences of external causes	13	50.15	17.990	21	82
15	External causes of morbidity and mortality	6	50.50	16.392	30	74
16	Other causes	7	42.43	16.359	20	65
17	More than one disease (as cause of death)	22	53.23	19.437	20	85
18	Without reference/unknown		52.72	18.898	20	98

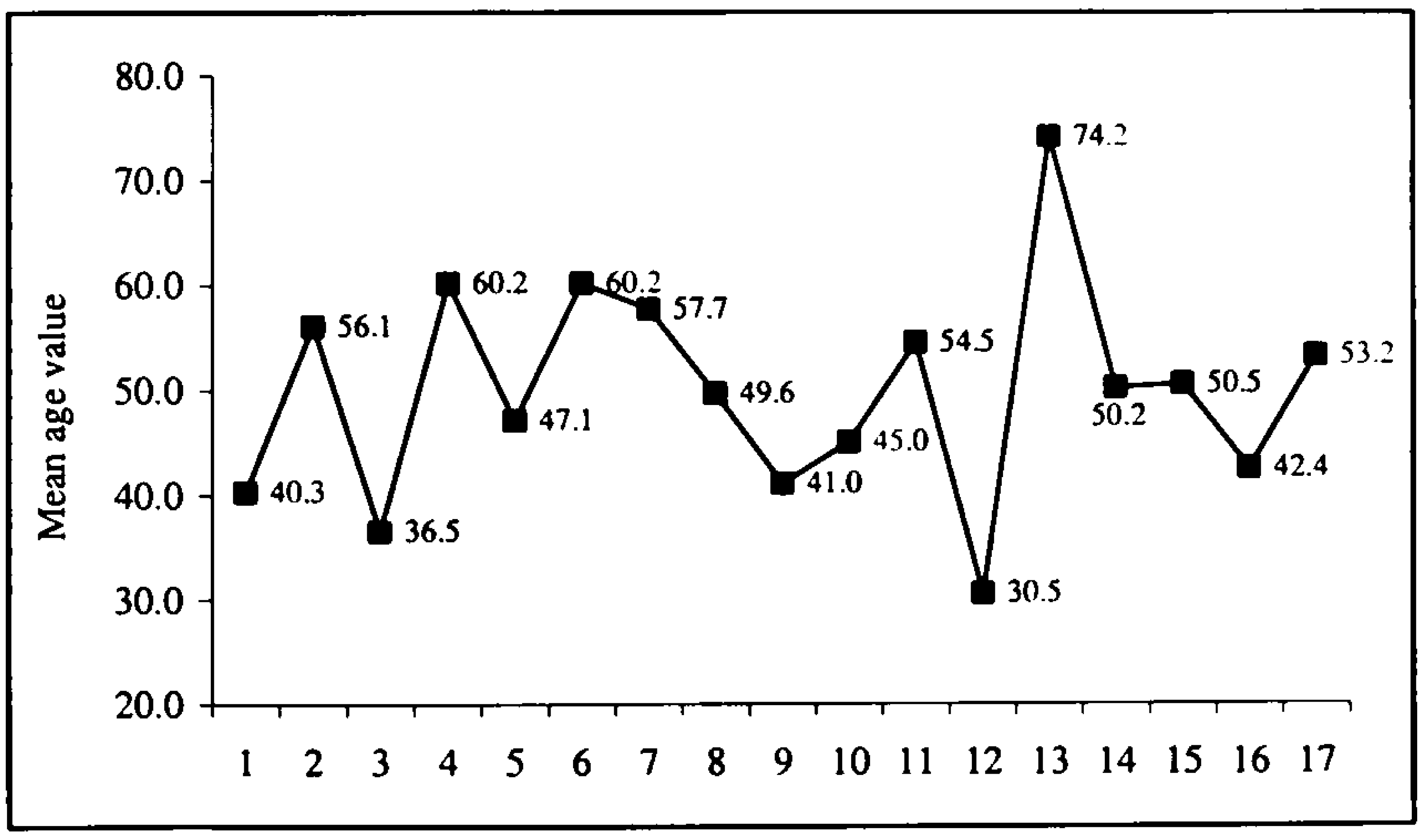

Figure 24 –Mean values of individuals' age at by cause of death (see Table 11 for number definitions).

According to data from the Portuguese *Instituto Nacional de Estatística* (I.N.E. 1887, 1949, 1960), the causes of death found in the sample were similar to those recorded for the entire population throughout the late 19th and early to mid 20th century. However, some considerations need to be made with regard to current "disease grouping" practise, as well as with regard to "disease classification" during the late 19th-century Portugal. Significant changes in language from the 19th and 20th centuries are a factor to be taken into consideration. Differences in meanings and spelling throughout the period under study account for some of the difficulties in the categorization of causes of death. But the major obstacle to overcome was the lack of specificity of some diseases reported as cause of death. The most striking examples are those addressing diseases of the circularity system, or neoplasias. This lack of specificity can also be found in the records of the *Instituto Nacional de Estatística* (National Institute of Statistic). Hence, this apparent mal-practice of cause of death diagnosis may only be a reflection of the medical knowledge at the time. An illustrative example is given in Figure 25.

ANNOS	CAUSAS DE MORTE														
	Doenças geraes	Doenças do systema nervoso e dos sentidos	Doenças do apparelho circulatorio	Doenças do apparelho respiratorio	Doenças do apparelho digestivo	Doenças do apparelho genito-urinario	Doenças puerperaes	Doenças da pelle e do tecido connexivo	Doenças dos orgãos da locomoção	Recemnascidos (Doenças diversas)	Cachexia senil	Mortes violentas (1) Accidentaes	Mortes violentas (1) Voluntarias	Mortes violentas (1) Criminosas	Molestias não classificadas
1885...........	1:266	944	490	2:195	536	131	28	91	60	260	290	28	22	1	114
1881...........	808	880	477	1:726	571	127	20	84	59	212	261	12	19	1	168

(1) Não se inclue um obito por ser ignorada a causa.

Figure 25 – Statistical yearly report of causes of death, according to disease grouping, per 1:1000 inhabitants for the *Concelho* of Lisbon between 1881-1885 (M.O.P.C.I., 1887: 36).

As depicted in the figure, the categorization of the causes of death in the *Concelho* of Lisbon, between 1881 and 1885, is extremely ambiguous with regard to the diseases it covers. The most ambiguous groups are those of (from left to right in the figure): the general diseases (doenças geraes), diseases of the nervous system and senses (doenças do systema nervoso e dos sentidos), and cachexia senile (cachexia senil). This is not to say that in the remaining cases the cause of death is straightforward; simply that it has been allocated to a particular anatomical system (such as respiratory and circulatory), diminishing the ambiguity of the cause of death. In conclusion, therefore, all groups gave little data concerning the real cause of death, leaving a very wide range of possible causes.

During that time period (1881-1885), the diseases of the respiratory system were the major cause of death. What was categorized as *doenças do systema nervoso e dos sentidos* (diseases of the "senses and nervous system") occupied the second most common cause of death. Finally, diseases of the circulatory and digestive system occupied the third most common cause of death (M.O.P.C.I., 1887). The older individuals, aged 60 or more, had as the principal cause of death "senile cachexia," certainly a reflection of their overall poor health. The condition is described by *Oxford English Dictionary* as "a depraved condition of the body, in which nutrition is everywhere defective" (Oxford, 1989). The younger individuals were distributed among all the other groups.

In the following yearly statistical reports, the causes of death were more precise, undoubtedly reflecting advances in science (Appendix_Material, Table 1). It was also interesting to note that the hierarchy of causes of death remained largely the same. For instance, between 1900 and 1902 infectious and parasitic diseases were the principal causes of death, of which tuberculosis stands out. Other respiratory diseases, such as bronchitis and pneumonia, were also amongst the major causes of death, followed by lesions of the heart and diseases of the digestive system (D.G.E., 1908). A similar trend was observed between 1960 and 1965 (I.N.E., 1961, 1966b). By the year 1955 causes of death due to road accidents, most of which happening in Lisbon, started to be specified in the early reports (I.N.E., 1956). Before that they were not explicitly reported, and were classified as causes of death due to accidents, poisoning and violence (I.N.E., 1953). These later refinements in classification were certainly a reflection of Portugal's development, and the increase of the population's access to "mechanical goods." In all, the changes in cause-of-death grouping certainly reflected the progress in medical knowledge. It was also illustrative of the overall previous simplification of cause-of-death assessment. Within this framework, it become apparent that only a partial representation of diseases behind the mortality rates can be glanced from such data, particularly when addressing the early years of the 19th and 20th centuries.

Curiously, both samples under study did not reflect the recurrent epidemics that affected the country in the 19th and 20th centuries, either in number of death per decade or in causes of death. The epidemics of cholera and yellow fever in 1833, 1855-1857, typhoid fever in 1872 and 1875, influenza in 1890-1891, and several other contagious maladies in 1896-1897, would have a major impact on the governments, which were forced to address populational health issues, so far absent in the political agenda. Consequently, from 1852 onwards many laws were implemented to improve public health (Queiroz and Rugg, 2003; Saraiva, 2003; Veiga, 2004). Ironically, these attempts would sometimes clash with the religious fervour of the population, especially in rural areas. One of these best known examples is the *Revolution of Maria da Fonte* that took place in 1846. This was a popular riot that expressed the discontent towards, and unwillingness to obey the law stipulating that from henceforth "the dead" were to be buried outside the churches (Queiroz and Rugg, 2003; Saraiva, 2003).[41]

If the above mentioned epidemics, despite having an impact on the population, are only barely represented the baseline sample, then tuberculosis stands as one of the major causes of death. Indeed tuberculosis was, from the mid 19th century onwards, one of the major causes of death of Portuguese population (Santos, 1999, 2000). Data recovered from the yearly statistical reports testify to this trend; furthermore,

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[41] The European cholera epidemics of the 1830s, and other epidemics that followed, spread beyond the rural communities, into the villages and eventually towns. As a consequence, in 1844 the government introduced new regulations as part of the "Health Laws." These regulations were not welcomed by the rural people, as they considered it to be an attack upon Christian burial rites. The indignation amongst the population was such that it resulted in rebellious behaviour; one of them took place in 1846 and was named after the woman who started the protest - *Maria da Fonte*. Succeeding epidemics resulted in greater popular support, and understanding, and "colourful" episodes such as this became part of the folklore (Portela and Queiroz, 1999; Queiroz and Rugg, 2003).

bioarchaeological studies performed in both identified skeletal collections, CISC and LLSC, have complemented such a fact (Matos, 2003; Matos and Santos, 2006; Santos, 2000; Santos and Roberts, 2006).

Death due to tuberculosis was particularly incident in the major city centres, not only due to the pathogenesis of the disease, but also as a result of the increase in population density, poor living conditions, and population malnourishment (Paul, 1945). This combination of factors was easily found in 19th and 20th Portuguese cities. For instance, and as described by José Cid (1902), between the years of 1885 and 1900, 17.2% of deaths in Coimbra were caused by tuberculosis. Typhoid fever and influenza were other infectious diseases affecting the population. Other seasonal infections were pneumonia, bronchopneumonia and bronchitis. These later, accounted for 26.7% of the deaths. They were followed by diseases of the heart, tumours, and finally by violent causes of death such as suicide. Debility and senility were also reported, these mainly affecting the elderly stratum of society (Cid, 1902).
José Cid (1902) specifies the geographic location of the city, its poor and practically non-existent sanitation, the city streets (narrow and dark), the houses (humid, unhealthy and of restricted size), the relative poor state of nourishment of the people, plus their working and living conditions, as contributory factors to the development and spread of diseases such as tuberculosis (Cid, 1902). These conditions were optimal for the spread of infectious diseases; not only tuberculosis, but also typhoid, malaria and cholera amongst others. These could easily find their way into the Coimbra population by direct contamination and/or indirect contact with contaminated water and soils, particularly in the case of cholera and typhoid fever (Cid, 1902). Diseases related with soil and water pollution, were a frequent and a major concern for public health in Coimbra. For example, in 1887 there was a typhoid epidemic due to direct pollution of the water of the "*fontaneiras*" (water

fountains) in the high part of the city – *a Alta*.[42] Given such circumstances, it was not very surprising that diseases such as enteritis, bronchopneumonia, pneumonia, diarrhoea and others were a constant problem for this population, particularly amongst those who lived in the lower part of the city – *a Baixa*. This area suffered due to major sanitary problems as a result of the constant flooding of the river Mondego (Cid, 1902).

The migration of people to the major city centres, particularly during the late 19th and early 20th century, imposed serious constraints on the cities. The increase in population was contributing to the overall impoverishment of the city, with a concomitant devastation of the population's health. The increase in populational density revealed that cities such as Lisbon, Porto and Coimbra (to a lesser degree) were unprepared to deal with the mass of newcomers. It brought with it problems of disease, habitability[43] and crime (Garnel, 2002b, 2003b, 2005). The fact that tuberculosis, and other diseases, increased coincident with the influx and increase of "working-classes" in the cities, led to the assumption of causal connection between the two. Consequently, the working-classes became the principal target of medical discourse. This liaison, between medical discourse and societal control was explored by Maria Rito Lino Garnel (2002a, 2003a, 2005). Her work discusses the relationship established between medical power and its influence in the overall control of the population, and of women particularly. This came about through the implementation

[42] It is necessary to clarify that the city was, and still is, divided into three topographic zones: the high part of the city – *a Alta*, the low part of the city – *a Baixa*, and the suburban area. Each one of these possessess distinctive characteristics, not only in the geographic sense, but also socially and economically (Cid, 1902). The high zone of the city, known as the *Alta*, was composed mostly of ecclesiastics, students, teachers, and other people related to academia, with a high percentage of adults and teenagers. This "group" of the population was highly migrant, as it was composed mostly of students who would only come to town to study, during term times, and then would leave (Roque, 1988). The low part of the city, the *Baixa*, had the major part of the commercial sector of the city, and was composed mostly of the resident population. The *Baixa* topography was, and still is, very dark, and humid, with narrow, unhealthy and winding streets. The sub-urban area was similar to the rural landscape, and mostly composed of peasants as well as land owners. Although poor, the living conditions were better. The population could always rely on a slightly healthier environment than those experienced in the city due to the less crowded occupation areas and less contaminated water and soil; people could always depend (to a certain extent) on what the land had to offer (Teixeira, 1992). The impression given is that individuals living in the *Alta* would be slightly healthier than the individuals living in the *Baixa*.

[43] The improvement of housing conditions became a growing political, economical and social concern due to an increase in mortality, partially as a consequence of the many epidemics felt in Portugal, but it was also related to poorer living conditions. Between 1901 and 1903 the government made an effort to pass laws aiming to improve overall housing conditions of the population (Ferreira, 1994; Pereira, 1994; Teixeira, 1992). Low cost housing complexes such as *Bairro do Arco do Cego* and *Bairro da Ajuda* built in Lisbon in 1919 and 1920 respectively, were examples of the government efforts to improve the population's living standards. Despite its effort neither the 1st Republic, or later on the *Estado Novo*, were able to prevent the appearance of shanty towns on the outskirts of Lisbon. The city ultimately grew beyond the government's control (Vaquinhas, 1993).

of sanitary rules that aimed to improve the cities' living-conditions, but which also contributed to the management of the working classes. Specifically, women were deemed as responsible for the "vices" of disease and crime affecting the cities, particularly Lisbon and Porto (Garnel, 2002b, 2003b, 2005). The "medical intervention" was aiming to improve the city landscape, providing it with better open spaces, gardens and trees, better sewer systems, streets and houses. By doing such, they were also be regulating the working classes, and segregating them from the privileged classes by a comfortable distance. The newcomers were to find places of lodging in what would become know as *Pátios* (Courtyards), similar in status to ghettos. Hence a sense of community became defined either by class, ethnicity, occupation or place of origin (Funchs, 2005).

The newcomers to the city would occupy old buildings located close to industrial areas. Most of these buildings were abandoned monasteries and convents, echoes of the extinction of the religious orders by the liberal government in 1834 (Pereira, 1994; Saraiva, 2003; Teixeira, 1992). Consequently, in the second half of the 19th century, the proliferation of *Pátios* was significant. This spontaneous new housing arrangement was characterised by a roofless inner courtyard, surrounded by several houses. The lack of privacy was another of its characteristics (Figure 26) (Pereira, 1994; Teixeira, 1992). In 1905 there were 233 *Pátios* in Lisbon, incorporating 2278 households for 10487 people (Matta, 1909). Apart from being overcrowded, the living conditions were miserable and hazardous to health; most of them had no running water, no basic sanitary conditions and were very dark and humid, as many of the dwellings were formerly abandoned houses, cellars or sheds (Pereira, 1994). Nevertheless, with time the *Pátios* become small communities that offered their occupants a network of cooperation and comfort, as portrayed in the film *O Pátio das Cantigas* (The Courtyard of Songs, 1942) (Figure 27). The film portrays the human relations in a Lisbon courtyard. The story explores the vivid neighbourhood bonds of friendship, love and rivalry.


Figure 26 – Example of a typical *Pátio* of 19th century Portugal. Notice the small street, the close neighbouring doors/households. The clothes hanging out to dry exemplify how women would carry out laundry work.

Figure 27 – Promotional poster for the film: *O Pátio das Cantigas* (1942). It makes reference to the importance of the human relations established between neighbours. There is also a sketch of what a *Pátio* looks like: a row of houses with a patio in the middle.

The film was directed by Francisco Ribeiro (1911-1984). The plot centres on the daily routine of a handful of people living in a typical Lisbon "pátio". The characters' dreams, disappointments, passions, jealousies and joys are explored, in an atmosphere of illusion that, no matter how hard life is, it is worth living.

With the development of new industries, another type of housing emerged in the topography of the Portuguese major cities, specifically Porto and Lisbon. They became an alternative to the *Pátios*, as they represented an improvement in the living conditions of the population, with better sanitary conditions. This new type of housing was known as *Vilas* (small villages). The *Vilas* reflected an investment of the private sector, as industries decided to build housing for their own workers, with a growing consciousness that keeping the workforce happy could pay financial and commercial dividends. This was the case of the *Companhia de Fiação e Tecidos Lisbonenses* in 1870 and of the *Campanhia Lisbonense de Estamparia e Tinturaria de Algodões* in 1885 (Teixeira, 1992). As a result, these *Vilas* were not only inhabited by the working class but also by small merchants, public service employees, armed forces and an ever growing middle class (Teixeira, 1992). The *Vilas* had a different layout than the *Pátios*. They were characterised by being composed of a row of similar buildings flanking a long street. The access to the *Vilas* could sometimes be done by an external archway. In other instances the *Vilas* would possess an internal patio, which would stimulate the community life (Matta, 1909; Pereira, 1994; Teixeira, 1992) (Figure 28).

Figure 28 – These are clear examples of the typology of *Vilas*. Left: *Vila Sousa* was built in 1890. The access to the *Vila* is made through the archway pictured. Right: *Vila Berta*, typical example of a street flanked with houses. This *Vila* dates from 1902 (http://www.cnc.pt).

Second to poor living conditions, but contributing enormously to the impoverished state of the population, was the general poor nourishment of the Portuguese population. Although regional variations were found, the dietary intake was very monotonous and unbalanced (Abecassis, 1951/1952; Campos, 1977; Nazareth, 1908; Pereira, 1994). The population's main dietary constituents included mostly "*broa*," similar to bread, made of cornflour or a mixture of corn and wheat flour, and soup, mainly made of potatoes and green or dried vegetables (e.g. beans) and seasoned with olive oil. On rare occasions cod or sardines were eaten but meat was a luxury not accessible to all and, when present, it consisted mostly of pork (Lopes, 2003; Vaquinhas, 1993). On the other hand, wine consumption, due in part to the development of viticulture, was by the late 19th century becoming a serious problem in Portugal to the point of being considered a "plague" (Vaquinhas, 1993). Ironically, the same inquiries reveal that the wealthier stratum of society was also "suffering," due to overindulgence (Garrette, 1936).

In conclusion, the deprived lifestyle of most of the Portuguese population could easily explain the predominance of infectious and parasitic diseases, as major causes of death. Living conditions, allied with a meagre diet, and the overall lack of resources of the majority of the population, all contributed to a borderline subsistence base were opportunistic diseases could effortlessly occur. The relevance of the issues addressed in this section is that they provide a clear and concise view on the living conditions of the majority of the Portuguese population of the late 19th and early 20th century. These conditions influenced demographic variables, as well as the social variables. The social economical factors were actively influencing by the overall behaviour of the population. Gender roles were being shaped within the mutation of the cities, and the dynamics of the social classes. Many of the newcomers were countryside people that were migrating to the city.

5.2.5 Sample occupational groups

All individuals used in this research had known occupation. This data was is part of their biographical information associated with the individuals of the identified collections. Their grouping by profession was done using the 1951 Registrar General (Armstrong, 1972), and the categories employed by João Roque (1988) in his analysis of the *Freguesia da Sé* of Coimbra. The data was also compared with the British census from 1841-1891,[44] so that a translation of the occupations, from Portuguese to English, could be made. This proved troublesome, as a translation from Portuguese to its English equivalent was only possible when descriptions of the "duties performed" were available. Ultimately, individuals were categorized into seven occupational groups (Table 12). The allocation of the individuals to the various categories was done accordingly to the descriptions provided by Armstrong (1972) and Roque (1988).

[44] Consulted in: http://www.nationalarchives.gov.uk

Table 12 – Distribution of sample according to occupational group.

Occupational Groups	N	%
Government administration/Services	53	8.79
Commerce/Transport	84	13.93
Skilled workers/Artisans	101	16.75
Farmers/Servants	29	4.81
Unskilled workers	37	6.14
Army/Navy	23	3.81
Doméstica	276	45.77

A clarification is necessary with regard to the number of females allocated to the group *Doméstica*. This category is solely represented by women, whose occupation was described as such. This was a major problem in the current research, which aimed to distinguish patterns of gender-related behaviour based on occupational skeletal changes. The fact that many of the women were described as *domésticas*, rendered the gender distinction, from a paleopathological perspective extremely difficult. Overall, the division of the female sample according to occupational groups was that most women were employed, or were performing domestic activities 91.1% (276/303). The rare exceptions to this classification were seventeen (5.6%) servants, four (1.3%) seamstresses, and the occasional farmer, nurse, proprietor, post-office employee, student and teacher. These latter constituted the remaining 2% of the female sample.

Male distribution per occupation strongly contrasted with the female results. Males had a remarkably detailed gallery of occupations (see Table 2; Appendix_Material). A total of eighty three occupations were reported for men: 32.3% (97/300) were allocated to the Skilled Workers/Artisans group, 28% (84/300) to commerce and transport, 16% (48/300) to government administration and services, 12.3% (37/300) represented unskilled workers, 7.7% (23/300) were, or had been employed in the army or navy, and finally, 3.7% (11/300) worked as farmers, or related occupations, and as servants.

Statistically significant differences were found between collections, and the distribution of individuals by occupational group ($\chi^2_{(6)}$=42.962, p<0.001, two-tailed significance). The LLSC was mostly composed of individuals working in governmental administration, services, commerce and transport; whilst in the CISC unskilled workers, farmers and servants predominated. The percentage of skilled workers and artisans in both sub-samples was similar, although slightly higher in the CISC.

The statistically significant differences between collections and occupational groups can easily be explained. The higher number of individuals working in administrative services found in the LLSC relates to the fact that Lisbon was the Portuguese capital. All governmental administration services were concentrated in Lisbon. On the other hand, Coimbra was a distinctly rural district, therefore favouring the presence of agriculture related occupations (Table 13). Overall, the majority of the individuals from both collections represented people from the low to middle socio-economic strata; this is particularly true for the CISC. However, this statement is based primarily on the occupational profiles of the males. The equivocal information regarding females' occupations prevents major inferences about their occupational profile, and consequently of their socio-economic status.

Table 13 - Distribution of individuals according to occupational groups: collections sub-sample and total.

Collection		Government administration/Services	Commerce/ Transport	Skilled workers/Artisans	Farmers/Servants	Unskilled workers	Army/Navy	Housewives
Lisbon	N	36	54	45	2	12	9	146
	% within Collection	11.8	17.8	14.8	0.7	3.9	3.0	48.0
Coimbra	N	17	30	56	27	25	14	130
	% within Collection	5.7	10.0	18.7	9.0	8.4	4.7	43.5
Total	N	53	84	101	29	37	23	276
	% of Total	8.8	13.9	16.7	4.8	6.1	3.8	45.8

Population occupation/activities during 19th and 20th centuries

In the 19th and early to mid 20th centuries a high percentage of the Portuguese population was employed, directly or indirectly, in agriculture.[45] Not only men but

[45] In the last decade of the 19th century 85% of the country's population was rural, 59.3% of which worked in agriculture and other related jobs, that is, in the primary sector (Martins, 1997; Vaquinhas and Cascão, 1993). More liberal, or literate professions, such as doctors, lawyers, attorneys, occupied no more than 1.4% of the population, and industry around 22% (D.G.E., 1924). In 1919, 57.7% of the population was still working in agriculture, and related jobs, 20.6% in industry and 6.4% in commerce (I.N.E., 1966a). Not many changes were observed between the years 1940 and 1965, apart from slight variations in the percentages (I.N.E., 1966a, 1976). In all, the primary sector was the major employer of the Portuguese population throughout the 19th and most of the 20th centuries.

also women and children were an important part of this workforce.[46] Consequently, the population was largely illiterate,[47] and adjectives such as "simple" and "naïve" were frequently used to describe the rural population who retained an uncomplicated lifestyle typified by firm religious convictions and a deep belief in tradition (Vaquinhas, 1993; Vaquinhas and Cascão, 1993). Education was largely denied, as literacy was deemed unimportant for those whose sole purpose in life was to work the land. The lack of investment in education suited the wealthy landowners, as they were also the main legislators; an educated workforce could be much less easily exploited. One of the major consequences of the intellectual impoverishment of the country was the slow industrial development, or even its absence, in certain areas of the country. The echoes of the Industrial Revolution were hardly felt during the 19th century, contrasting sharply with the rest of the western world. For instance, the only road that connected the north and south of the country, that is Porto and Lisbon, dated from the reign of D. Maria I (1734-1816). Only in 1849 did the construction of major new roads take place, and in 1852 began the constructions of the railways; Porto and Lisbon would remain unconnected by rail until 1864 (Saraiva, 2003).

[46] According to the state statistics, in 1960, a significant number of individuals aged 14 or less had an occupation (5%). These was mainly confined to the rural areas (Martins, 1997). Although men were the major work force in the cities, a lot of local traditional industries employed women and children. In 1890 36% of the active population were women working mostly in agriculture and textiles (Teixeira, 1992). The exodus of men to the cities decreased the number of agricultural workers, and consequently women and children were soon to be called to replace them (D.G.E., 1908).

[47] According to the statistical annual report of 1904/1904 (D.G.E., 1924), in 1890, 77.3% of the population aged above 20 years was illiterate. When sexes are considered separately, 67% of males were unable to read of write, contrasting with the staggering 85% of women. In 1911 (I.N.E., 1961) the percentage dropped to 72%, but females still presented higher values than males (79% *versus* 64%). These differences were greater when urban and rural areas were compared. Illiteracy was even more pronounced in rural women (in 1911, 88% of the women of the district of Coimbra were unable to read or write). By 1950 (Saraiva, 2003) the percentage of uneducated people had dropped to 40.4%, largely composed of the older individuals of the population, reflecting a past of "unattended education". The decrease in illiteracy was partially a consequence of the increase in number of schools. Between 1834 and 1910 schools increased from 1000 to 4500, boosted by the development of roads and railways. However, the teaching level remained low, as the teachers were largely untrained (I.N.E., 1961; Saraiva, 2003). The further one lived from the main cities, namely Porto and Lisbon, the poorer the education provided. In 1901 there were 346 schools in Lisbon, whilst only 290 in Coimbra. Likewise, education was not only a privilege of the rich, but also of men. The majority of schools were males (58% *versus* 32% females' schools in 1905, with the remaining 10% representing mixed schools). This overall pattern of teaching, and access to education, was maintained until the mid to late 20th century. Subsequent reforms, specifically during the *Estado Novo* (1933-1974), allowed a better and widespread access to education; but regardless of those efforts, in 1950 the percentage of illiterates was still 40.4%, and by 1960 it had only decreased to 38% (D.G.E., 1931). The general lack of enthusiasm for education reflected the pessimistic social reality. The lack of proper schools, teaching material and teachers, allied with the fact that teachers earned desperately low wages throughout much of the century, were severe limiting factors for the development of education. In 1914 a primary school teacher would earn 0$49 *escudos* a month, whilst a judge would earn 6$55 *escudos* [the *escudo* was the last Portuguese coin before the Euro in 2002. One Euro correspons to 200.482 *escudos*] and a army officer 1$39; in 1930 the corresponding salaries would be 21$03, 90$96 and 45$49 (Saraiva, 2003). The first teacher training schools were only developed after 1860; before that period each primary school was under the jurisdiction of the municipality of each region, which regarded school as unnecessary, due to the lack of money for investment, and because they did not fit the purposes of the major landowners (Garnel, 2002b, 2005).

As previously mentioned, the main occupation of the Portuguese population was agriculture and related works, and the majority lived in rural areas. This generalist description of the Portuguese population fits much of the overall population of continental European (Funchs, 2005). However, this rural "identity" was not homogeneous, i.e. the countryside possessed a variety of "peasant" categories distributed between rich and small landowners, tenant farmers, sharecroppers, landless day labourers (known as *jornaleiros* in Portugal) and dependent poor. These later two "categories" would correspond to the poorest of all, as they worked only on short, mostly seasonal, term bases, without future guaranties of earnings. They were therefore highly dependent the seasonal and commercial oscillations (Cascão, 1978; Funchs, 2005; Martins, 1997; Vaquinhas, 1993). With the advancements in industrialization, mechanization and capitalism, changes occurred. The countryside became "populated" with more artisans, craft shops and small business; and in the major cities industries were prospering. Consequently the overall occupational composition of European cities, Portugal inclusive, changed. Although agriculture was still a major occupation, in the cities factory work, services and commerce employment were beginning to characterized the population (Funchs, 2005).

Another important feature of the agricultural work is the lack of remuneration. That is, to have an occupation, as described in the populational census, did not necessarily mean to have a wage (I.N.E., 1976). Many women and children would work in the fields to help the family income. There were also cases of cooperation between neighbours. This was particularly true in the harvesting times, such as *vindimas* (grape harvest) (Figure 29).

  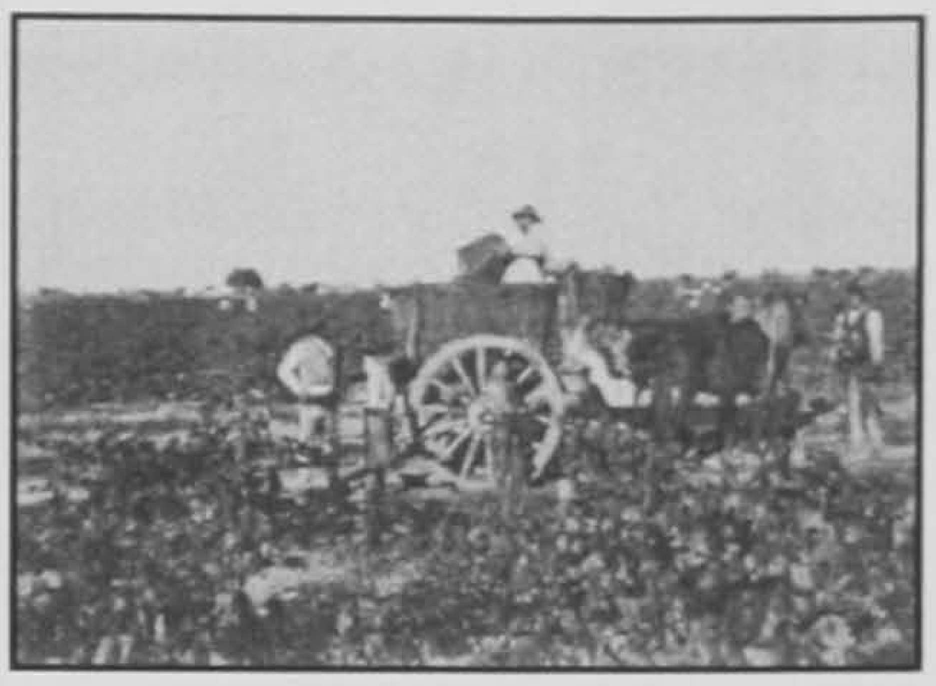

Figure 29 – From left to right: women and children working in the fields. Far right: people working in the harvest of grapes – *vindimas*[48].

One of the major difficulties felt, when categorizing individual's occupations, was the vagueness associated with some of the terminology used in the description of the occupations. As already described for the rural occupations, people working the land could represent different economical backgrounds as well as occupational duties: the word *lavrador/agricultor* (farmer) could be used to name a number of different categories (tenant farmers, sharecroppers, landless day labourers or dependent poor). The term could even refer to wealthy landowners. However, in the latter case the individuals would be certainly referred to as *proprietário* (owner) (Ribeiro, 1998; Roque, 1988).

Another occupational category which as extremely ambiguous was that described as trabalhador (worker – described in the sample as unskilled worker). The ambiguity here is not related with the socio-economic status of the individual in question, as it would be a lower class worker, but with regard to the type of activity performed. It would certainly refer to non-specialized, unskilled men who rendered many and varied services in both the countryside and cities (Figure 30). Regardless, the only certainty would be that their wage would be a very low one, and that their living conditions would therefore reflect this. Typically, such workers would struggle to buy food, clothes, medical care and any kind of comfort on a daily basis (Lopes, 2003; Mendes, 1993; Ribeiro, 1998; Vaquinhas, 1993).

[48] The pictures portray rural activities of the early 20th century. Original description of the photos (from left to right): "Trabalhos agrícolas - malhar o centeio na eira" (HACML, 1900, PT/AMLSB/AF/POR/054662);
"Crianças no trabalho agrícola", (HACML, 1900, PT/AMLSB/AF/POR/054620);
"Carregando um carro de bois com uma dorna cheia de uvas durante as vindimas", (HACML, 1911, PT/AMLSB/AF/ACU/002180).

Figure 30 – Example of activities performed by *trabalhadores*. In the 19th and beginning of the 20th centuries, unskilled workers would be employed in rural activities. From the 20th century onwards and as a consequence of the exodus to the cities they would be recruited to undertake industrial work (left to right)[49].

Other activities of dubious description found in official records include those of *proprietário* (male)/*proprietária* (female), the English translation being an unspecified proprietor; *empregados de comércio* (shop assistant) and *comerciante* (shop owner). They are dubious in the sense that a given category, such as that of shop assistant, would describe individuals working not only in small groceries, but also in a fashionable patisserie. The work performed would be similar, but the social status would be profoundly different. The social position of an individual would not only be based on the work performed, but also on access to resources, which ultimately would shape their overall social condition (Figure 31).

[49] Original description of the photos and reference (from left to right):
"Trabalhadores cuidam de redes e de cabos" (HACML, nd, PT/AMLSB/AF/POR/054541);
"Trabalhadores agrícolas" (HRCML, nd, PT/AMLSB/AF/ACU/000980);
"Trabalhos agrícolas" (HACML, nd, PT/AMLSB/AF/JBN/003593).

Figure 31 – The examples given illustrate the variation in the category of "shop assistant." The top row depicts upper class fashionable shops. The lower pictures represent shops frequented by the working class and middle class.[50]

Major wage differences were found between people working in the land, or in more specialized crafts. Differences were also pronounced when the salaries of men and women were compared, as well as those from cities and countryside. On average, male salaries were double those paid to women for the same work. In 1930 a male rural worker would earn between 8$85 and 10$85 *escudos*, and a woman 4$85 and 6$ 05, the variation within each being due to regional differences, in this case between Lisbon and Coimbra (D.G.E., 1931). By 1960, however, the average monthly salary had increased: in Lisbon, a man working in agriculture and related jobs, could earn between 34$ and 49$, whilst a woman engaged in the same activity would be paid 17$ to 29$ *escudos*; in Coimbra men and women employed in the same task would be earning between 24$ to 30$ *escudos* and 13$ to 16$ *escudos*, respectively (I.N.E., 1961). By comparison, a skilled professional, such as a carpenter or a driver could earn as much as 42$ to 45$ *escudos*, and an unskilled worker would be in the lower payment rank, with an average of 25$ *escudos* per month (I.N.E., 1961).

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[50] Original description of the photos and reference (from top, left to right; bottom, left to right):
"Pastelaria Foz no edifício do Palácio Foz" (HACML, 1918, PT/AMLSB/AF/JBN/001779);
"Loja Parisience" (HACML, nd, PT/AMLSB/AF/LIM/002600);
"Pavilhão Chinez, mercearia e pastelaria" (HACML, nd, 1908, PT/AMLSB/AF/JBN/001012);
"Casa Figueiredo & Cª -Sobrinho, loja de ferragens e de louças de esmalte" (HACML, nd, PT/AMLSB/AF/JBN/001004).

Apart from the overall vagueness of some occupational terms used in the records and mentioned above, another obstacle felt whilst characterizing the sample occupational profile was the discriminate treatment given to the description of women's occupations. While most men were assigned to a specific activity such as carpentry, shoemaking, masonry, bricklaying, teaching or armed forces, almost all women are described as *doméstica*. This is particularly true in the early census of the population, but is also visible in the census of the mid 20th century (I.N.E., 1945). The invisibility of the varied female occupations in the official records certainly reflects the secondary social position given to women in Portuguese society at that time. Although they represented a significant portion of the Portuguese workforce, particularly after the massive emigration of men, they were attributed a secondary role.

This lack of descriptive information about female occupations was one of the major obstacles in the occupational characterization of the sample. Undoubtedly females were mostly engaged in activities related to domestic services, or household chores, but they would also be performing tasks such as farming, commerce, and craftwork (Guinote, 1997; Roque, 1988; Vaquinhas, 1993, 1995). Many of the industries in the early 19th and even from the middle to late 20th century were familiar and traditional industries, employing not only the men of the house but also women and children. Consequently, being *doméstica* could be translated into domestic, housekeeper, housewife or even maid. However, each translation possesses different meanings with regard to the task performed, as well as its associated social position. The main question is: were these Portuguese women housekeepers, housewives or maids? And did this description convey the actual and varied work they carried out?

Figure 32 – Examples of female occupations: *jornaleira*/farmer, peddler, stall seller, civil servant, seamstress, unskilled worker, factory employee, launderer, nanny, maid and finally waitress[51].

We may never be able to confidently ascertain the precise nature of a woman's work from such records; in the context of late 19th /early 20th century Portuguese life the word *doméstica* would be used to represent all the above, and more (Guinote, 1997; Roque, 1988). All the services performed by women would be generalised to the extreme, and were ultimately grouped into a single category, reflecting the societal notion that a "woman's place" was in the house. The records of women's activities are incomplete, disregarding the varied natures of women's work. Consequently, in

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[51] Description of the photos and reference (from left to right, top to bottom,):
"Ceifeiras" (HACML,1940-1959, PT/AMLSB/AF/PAS/002929);
"Vendedoras de figos transportando os cestos à cabeça, após a descarga no cais da Ribeira Nova" (HACML, 1912, PT/AMLSB/AF/JBN/000742);
"Vendedora de figos no mercado da Ribeira Nova" (HACML ,1910, PT/AMLSB/AF/JBN/000744);
"Funcionárias da Junta de Crédito Público. Actual Instituto de Gestão do Crédito Público" (HACML, 1911, PT/AMLSB/AF/JBN/001256);
"Atelier de costura da casa Paris em Lisboa" (HACML, 1911, PT/AMLSB/AF/JBN/002335);
"Greve dos operários da CUF - Companhia União Fabril" (HACML, 1911, PT/AMLSB/AF/JBN/001096); "Lavadeiras" (HACML, 1908, PT/AMLSB/AF/JBN/000128);
"Ama com crianças num banco de jardim da Avenida da Liberdade" (HACML, 1912, PT/AMLSB/AF/JBN/000159);
"A criada penteia a sua senhora" (HACML, nd, PT/AMLSB/AF/JBN/002275);
"Sala de refeições" (HACML, PT/AMLSB/AF/ACU/002239).

the present research no significant socio-economic inferences could be made for female occupations.

In conclusion, with the exception of the description of female occupations (almost all classified as *domésticas)*, the sample studied barely reflects the occupational profile of the 19^{th} and 20^{th} century Portuguese population. One would expect a higher percentage of individuals classified as farmers, servants and unskilled workers. In both samples selected, and the overall collection, men were mostly employed as skilled workers/artisans, in commerce or transport, and in the administrative services. However, the correlation with the occupational status of the individuals and the one expected based on historical data, may only reflect the availability of individuals for collection, and may not be a reliable representation of the population in general. On the other hand, the relatively high percentage of these particular occupations fit the profile of urban communities, where services and commerce would play a major role in the city's economic dynamics. Therefore, despite not being congruent with the occupational distribution of the Portuguese population, in general the profile of the sample and collections fit a "city profile."

5.2.6 Summary of the sample under study

A total of 603 skeletons were studied: 299 skeletons from the CISC (149 males and 150 females) and 303 skeletons from the LLSC (151 males and 153 females). The sample represents individuals that were born between 1822 and 1935, and who died between 1891 and 1965; the age at death of the total sample ranges from 20 to 98 years. With regard to occupation, women were primarily classified as *domésticas*, whilst men were mostly employed as skilled workers and artisans, and in commerce and transport. The categories for males included: government administration and services, unskilled workers, army or navy, and farming or related works.

5.3 Society: working women and working men

The following section complements the historical, social and economical data discussed the in the previous sections of this chapter. It will briefly explore social class and male and female relationships. The importance of this short overview is to introduce the theme of gender into the Portuguese context of the sexual division of labour during 19th and mid 20th centuries. This will be of extreme importance when discussing the results of the analysis of the markers of occupation stress, and if they bear any relation to gender.

With the advent of the Industrial Revolution, deep economic, social and political transformations took place in society. These changes provoked a rupture within the traditional models and values of society (Vaquinhas, 2000). The countryside and agricultural economy were replaced by an industrialised economic base, in which the lower classes of society aspired to improve their social conditions: "Low-income men and women were not part of a subculture; many aspired to and struggled to lead a respectable and hygienic lifestyle with an adequate income" (Funchs, 2005: 195). This statement was as true for the rest of Europe, as it was for Portugal.

During the 19th century, whilst the poorest Portuguese were migrating from the country mostly to the cities, the aristocracy was crumbling, and a newly wealthy *bourgeoisie* was emerging as the new ruling class. Ultimately, as in many other European countries, the *bourgeoisie* and aristocracy became important allies, discriminating against the lower classes which were composed of peasants and of the embryonic industrial working class (Vaquinhas and Cascão, 1993). The new *bourgeoisie* was composed of large scale landowners, financiers and merchants. In their alliance with the aristocracy, many of them were proclaimed nobility, in recognition of their wealth and services rendered to the state; or more prosaically, as a mere result of an economic transaction (Vaquinhas and Cascão, 1993). Ironically, amongst the new upper class *bourgeoisie* were some former members of the rural poor, who had become wealthy after emigrating to Brazil. These emigrants were the epitome of the Self-made-Man. The social importance of this section of the *bourgeoisie* may be seen in the many caricatures of the *Brasileiro* (The Brazillian) in the popular press as well as literature, although not always for their most noble attributes. Despite their wealth and importance as economic pioneers, they were depicted by many as being narrow minded, illiterate and very conservative (Nunes, 2000; Vaquinhas and Cascão, 1993). Their wealth was flamboyantly and expressed in the new, luxurious constructions being added to the topography of Portuguese major cities, such as Lisbon. Further to the emerging new lifestyle, these newly-enriched bourgeoisies were demanding more and better quality goods, many of which were not produced in Portugal. Unable to produce these goods, Portugal had to import them, leading to a predictably negative effect upon the fine balance of the Portuguese economy (Vaquinhas and Cascão, 1993).

The new *bourgeoisie* introduced to Portugal new costumes and fashions, which were used as class differentiators, being only accessible to the wealthier classes. It also expressed a change in behaviour similar to the one observed in the rest of Europe: life was to be enjoyed, not merely lived. The "bathing resorts," horse races, public walks, theatre and clubs that echoed their high living standard were flourishing in Portugal (Dias, 2002; Vaquinhas and Cascão, 1993). Fashion became a class differentiating mechanism especially amongst young women. These were encouraged to display their family wealth, and young men used it as an identifier of women's inherent social position; indeed, in this respect of fashionable attire, one could find many similarities with the peacock's tail in Darwin's discourse of sexual selection (Vaquinhas and Cascão, 1993). The extravagance of some ladies toilettes was such that they became targeted by the sensationalist newspapers of the capital. (Figure 33). The objective was not only to satirize the extravagant outfits of the wealthier classes themselves, but also to criticize their way of life. Many felt that good, more traditional values and costumes were being lost, and to caricaturize these new fashions was a way to make this concern visible to the masses. The majority of the population could not read, but theses cartoons were very popular, and the end effect was easily achieved.

Figure 33 – Examples of the caricaturized female outfits. There is also a strong satirical note struck here, addressing the fact that ladies would marry older and wealthier gentlemen, who could afford for their extravagant lifestyle.

Left: "… the fashion statement is still the same, only more exaggerated and that the outfits are now equipped with breaks. Silk stockings are still used as gloves, and old rich men are still fashionable as husbands". *O Sorvete*, 7th year, n.341, p7, (16th of October, of 1884).[52]

Right: "Conveniences and inconveniences of the abuse of fashion". The reference is not only to the overall opulence of the outfit, but also a reference to the presence of the women's lover hidden under her skirt. One can only glimpse his feet (circled). *O Sorvete*, 7th year, n 342, p.8. (23rd, November, 1884).[53]

Fashion became a means by which the *bourgeoisie* could demonstrate their wealth and power, and hence a spectacle for the middle and working classes to satirize. Elegance and gender-beauty was highly praised by the *bourgeoisie*, particularly in the female body. During the 19th and early to mid 20th century it became a symbolic instrument of power, and an object of investment. The disparity between classes' wealth is better understood with an example: in 1909, a lady's hat would cost around 3000 réis (Portuguese coin before the escudo, and euro), but the wages of a landless female (*jornaleira)* day-labourer were a mere 140 réis (Vaquinhas, 2000: 53).

A second phase of social awareness came with the 1st Republic (1910-1926). The middle class bourgeoisie assumed a more prominent role in society, expressing the growing concerns of the lack of economic, industrial and social development of Portugal. They eventually ended up replacing the dominance of upper classes as the

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[52] Original description: "Novos figurinos para o inverno: - Continua a imperar o-sim-senhor mais augmentado, e com aparéelo para facilitar a conducção. As meias de sêda enfiadas pelas mãos ainda não perderam de moda, e continuam a usar-se para o passeio. (Os novos aparéelos teem o respectivo travão para as descidas.) A respeito de maridos a moda continua a preferir os velhos ricos…"

[53] Original description: "Conveniencias e inconveniencias dos abusos das modas"

root of social and economic changes. Their professed objective was more "noble" as they were aiming to improve the general living conditions of the people, as well as to implement social justice, particularly towards the working classes.

This middle class was mostly composed of the smaller commercial and industrial sectors, members of the liberal professions such as doctors, public service members, army (not higher posts), middle and small rural landowners, and students. They all shared the consciousness of belonging to an emergent social class, which could make a difference to the much deprived life-style of the cities, as the poorest conditions of the rural community were now being shared by the new working classes (Rodrigues and Baptista, 1996). The numerous strikes organized by the factory unions were a major reflection of working class discontent. But most of all, the strikes proved that the population was prepared to fight for their rights, and not only the men, but women also (Dias, 2000; Garnel, 2003b). This was particularly felt from 1839 onwards, with the formation of the first working-class unions (Mendes, 1993). During the next few years many hundreds of strikes took place. Between 1852 and 1910, the number of strikes was estimated at around 559. The demands of the workers were almost always the same: better salaries, fewer working hours and improvement of working conditions. (Martins, 1997; Mendes, 1993; Saraiva, 2003) (Figure 34).




Figure 34 – Striking workers in the streets of Lisbon, between 1911 and 1912.

Right side: electric strikes in 1912. Top, from left to right: textile industry strikes demanding protection laws against work accidents and reduction in working hours[54].

In the overall context of class segregation, 19th and 20th century Portugal was extremely patriarchal. Women were subservient to men, mostly fathers and husbands, but at the same time they would stand by their side if confronted by family "outsiders." This apparently contradictory behaviour was observed not only in Portugal, but also in other European countries (Funchs, 2005). The ideology which underpinned the subjection of women to men was based on the overall idea that women were weak, easily manipulated and very sensitive, hence the need for protection, whilst the dominating men were intelligent and brave. Women were without will of their own, and if a strong will was shown, it was interpreted as a

[54] Original description of photos, and references:
"Greve dos eléctricos, manifestação na praça do Comércio" (HACML, 1912, PT/AMLSB/AF/JBN/001453);
"A greve dos eléctricos, um carro da empresa Chora assaltado por populares que desejavam ser transportados" (HACML, 1912, PT/AMLSB/AF/JBN/001411);
"Operários da indústria têxtil que entregaram ao Parlamento uma petição sobre o projecto de lei dos acidentes de trabalho" (HACML, 1911, PT/AMLSB/AF/JBN/001476);
"Operários da indústria têxtil a caminho de São Bento onde entregaram uma petição pedindo o horário de trabalho de 8 horas e outras regalias" (HACML, 1911, PT/AMLSB/AF/JBN/001473).

manifestation of a pathological condition (Garnel, 2003a).[55] Access to resources, education and in a broader sense to life opportunities, was restricted to men, or women of the upper and middle class. Women of the lower or working classes saw much they desired. But even women, who had access to education, had a different curriculum than equivalent males: women were to be educated so that they could become excellent mothers and wives, and nothing more. However, women of the higher classes should be sophisticated and were coached to behave in high society circles, where *etiquette* and grace were essential.

Irene Vaquinhas' (2000) approach to the different status of women of lower, and upper class is referential in the analysis the discrimination between these two classes. *Mulheres* and *Senhoras* (Women and Ladies) encapsulated the divide felt within the female gender, with behaviour, language and appearance reinforcing the unequal social status. The first, *mulheres*, would reference to women of the lower class; the second, *Senhoras*, to the upper ladies of society. The women of lower classes were allowed more freedom of gestures, words and behaviour, they were considered "people of low quality" (Vaquinhas, 2000: 16). The upper class ladies were more refined, well behaved, educated, timid and modest. They were women of medium or

[55] The "normal" feminine behaviour was that of being obedient to the father, or husband. Failure to be so would result in the female's behaviour being associated with mental illness, ultimately legitimized by medical knowledge. The medical profession would act as a guardian of traditional models of social constructs, and punisher of any deviation from the norm. Maria Lino Rita Garnel (2000 - 2005) explored the use of medical knowledge in the end of 19th and early 20th century as a means of social implementation and maintenance of norms of behaviour (Garnel, 2002b, 2005). Individual and populational behaviours that deviated from the established norm would be considered dangerous and the results of a pathological state. The "shaping" of social categories was not only done in the realm of male and female gender, but within social classes. The targets were consistently females, and the lower classes. They were both credited with the ability to cause the most harm, and willingness of transgression. Crime, sexual depravation, syphilis, tuberculosis, alcoholism and riotous behaviour were used to define the working and lower classes, and especially women (Garnel, 2003a, 2005). Garnel presented two cases of females diagnosed with "insanity": one refers to a Rosa Calmon (1900 - 1901) and the other Adelaide Coelho da Cunha (1918-1921). The first defied the paternal power, the second her husband. Most importantly, they both transgressed the accepted values and social norms, and in both cases the medical experts diagnosed the women as "pathologically ill" (Vicente, 2001). To a certain extent, women were deprived of basic freedom as it is understood today. For instance; women were only allowed the vote in 1931, but this franchise was extended only to those with a high level of education (university or higher school), whilst for men the only demand was for them to know how to read or write; until 1969 women needed written permission from their husbands to travel abroad. In 1967, the lack of virginity at the time of marriage, was enough to nullify the union (Vaquinhas, 2001). Women were without political rights and without social-economic status of their own; they were always described in reference to men, as their daughters, sisters, wives and mothers (Vicente, 2001). Women's inherent inequality started to dissipate only after the 25th of April of 1974, the year of the Revolution (O corticeiro, 3-X-1929 in Dias, 2000: 73). However the deep-rooted patriarchal values, and norms still linger throughout Portugal's social behaviour.

high socio-economic status, who enjoying a comfortable and prosperous lifestyle (Mattoso, 1993; Vaquinhas, 2000; Vaquinhas and Cascão, 1993). Duality of rural and urban life was also expressed in the behaviour of women. The "women" were more outspoken of their rights, whilst the "ladies" would convey with the bourgeoisie social norms (Vaquinhas, 1995, 2000, 2001).

The overall segregation of women was also inbuilt in the general sexual division of labour. The sexual division of labour was more related to the social perception of "normal and non-normal" behaviour for men and women, than with the physical efforts allied to activities. Men would embrace more outdoor and physical jobs, either in factories of in the fields; whilst women would be responsible for the household chores. Men belonged in the public domain, women in the domestic one. But the women's "domestic realm" would extend beyond the household boundaries. They would have to manage their time between the fields and the house, between the animals and the children and husbands (Funchs, 2005). They would also work in the factories and as vendors on the streets. Women had limited power in the domestic domain, and little importance in the public scene (Garnel, 2002a). But the fact that they were to stay at home did not necessarily reflect a life of inactivity, as already explored in previous sections of this chapter. Women would engage in many different activities, similar to men, and these activities were not necessarily without physical demands or constraints. In the end, both men and women would be in a position to develop strong skeletal occupational markers, if these were to reflect physical activities. This was particularly true for the members of the lower and working classes, since individuals belonging to these social strata would be exposed to physical constraints from an early age.

The changes brought by industrialization increased the variety of the working classes' composition, especially for women. However, this proliferation of female work had a downside; it upset the social and economic male order. Family members were sometimes willing to forgo extra income from women's work outside the house, for an increase in non-material social capital. By staying at home the women were reinforcing the men's status as provider for his family, giving him a sense of pride and power. Families in which women were working outside the house were "castrating" the patriarch. As an alternative, some would work "outside" the house in their own home, i.e., they would undertake paid jobs such as laundry in their houses (Funchs, 2005). According to Joanna Brouke (1994), between 1860 and 1914, English women thought housewifery was a preferential role, when compared to paid secondary work, as it would allow them to maintain power over their life and household. In fact, several disadvantages of working outside the household are given: female workers would be vulnerable to employers, they would have a double work load, sometimes would spend more than they would earn (in clothes ripped, and travelling), would have difficulties taking care of the children, and a decrease in household living standards would be expected (Brouke, 1994). Working as a housewife would not necessarily render the women's work invisible. It would be particularly visible to their counterparts "who competed with each other and punished (through social ostracism and gossip) those who were seen as lowering standards" (Brouke, 1994: 197). Brouke's approach to housewifery work recognises it, not as confinement and limitation to women, but as a different level of social performance, one of neighbouring base. This concept fits perfectly into the Portuguese working class environment, shaped by the social organization of working classes into *Pátios* and *Vilas* (see section 5.2.4).

The productive activities of the city were gendered male, but that did not stop women from participating in that new universe, or factory working (and other occupations such as civil service and commerce, to name but a few), and compete with men (Funchs, 2005). A direct consequence of the "invasion" of this male gendered space was the discredit of women that worked in the factories. Further to being the targets of sexual harassment by the employees, specific occupational newspapers (Figure 35) were constantly aggravating women position as workers. "Middle-class reformers argued that factory work involving women's employment outside the home and mixing of sexes in the workplace had deleterious effect on working class families, on their morality, on their cleanliness, and on the well-being of their children" (Funchs, 2005: 111); a reality of both Europe and Portugal. Additionally, several newspapers of the time, and magazines, blamed many of society's "evils" on the fact that women had "abandoned" their home, and were seeking personal gratification. In all, Portuguese had a clear vision of how households, and society in general, should be "ruled": "Women as women, and men as men. For the women the house, for the men the factory [cottage industry]" (Dias, 2000: 73)[56].


O CHAPELEIRO

A NOSSA APPARIÇÃO

A Grève dos Chapeleiros


O FIANDEIRO

Figure 35 – example of two newspapers occupational-specific.

Left: *O Chapeliero* (The Hatter), 13th of August of 1905. There is a reference to a strike, and the appeal to other working classes for support.

Right: *O Fiandeiro* (The Threader), 9th of October of 1909. The articles describe the general deprived condition of this working class; low wages, bad working conditions and lack of employment stability. There is also reference to the international trade situstion for the textile industry.

In conclusion, the sexual division of labour in the 19th century had two dimensions, the house, and house chores dedicated to women; and the remaining activities, and public domain, for men. This simplistic division of labour hardly translates the diversity of female occupations, nor does it imply a complete subjugation of women to men. Although Portugal was a patriarchal society, women were in the early 20th century loudly expressing their views. The physical constraints existed both for men and women. Whether or not these could affect the bones of men and women differently will be discussed in the following chapters.

The overall assessment of the historical, economical and social context of 19th and early 20th century Portugal, made it apparent that sex-related activity changes may not be as indicative of gender as expected. Further, and as discussed during the Chapter of MOS analysis (Chapter 3), the viability of these markers as activity-specific or occupational-specific markers has been put into question. Additionally,

56 The original citation reads: "Mulheres como mulheres, homens como homens. Para a mulher o lar, para o homen a oficina." The *O Corticeiro*, is one of the many journal of a specific occupation. In this case, *corticeiros*, were individuals working in the cork industry.

the majority of men and women of the chronological period under analysis were engaged in physical activities from a young age, particularly those of the lower and working classes. This scenario fits the current sample under analysis, according to the results of the sample occupation (see section 5.2.5). Finally, due to the overall categorization of women as *domésticas* (translated in this work as housewives), one cannot compare specific female occupations with specific male occupations. This will not allow to control for sex bias occupational bony markers within a particular occupation. Considering the overall schema of knowledge, it would be interesting to consider an incursion into the realm of social class diversity, and its hierarchical construction, rather than gender, whilst analysing markers of occupational stress.

Chapter 6: Results I. Analysis of the degenerative bony changes (DBC), osteoarthritis (OA) and muscle stress markers (MSM)

In this chapter the results of the statistical analysis of DBC and MSM are presented. Observation of the DBC and MSM, per skeleton, varied accordingly to the state of presentation of the bones. Hence, the total number of individuals analysed for each variable varied accordingly. The major impediments to bone surface examination were post-mortem damage and missing areas required for observation, followed by other pathological lesions. These observations are valid for all statistical analysis performed.

This chapter is divided into two major groups of results, each with a brief summary of results. The first set corresponds to the analysis of DBC and OA; the second concerns MSM and DMSM analysis. The analyses of DBC focused on marginal lipping, porosity on the articular surface, osteophytes on the articular surface and eburnation. These were examined separately by articular surface of the several joints considered. The analysis of OA, by joints, was done accordingly to the methods outlined in the Chapter 4. The second set of results focus on MSM variables: one deals with the variables at an ordinal level (graded 0-3); the other set of results concerns a dichotomous variable, based on the presence and absence of the more severe degrees of lesion, that is, lesions recorded with grade 2 (moderate) and grade 3 (severe). As detailed in Chapter 4, the results based on these variables were referred to as DMSM. Finally, a conjoined discussion of the results will be made, with reference to individual aspects of DBC, OA, MSM and DMSM, as well as a conjoined discussion on issues related with methods and interpretation of the data.

For both set of results the statistical analysis will target bilateral asymmetry, sex-related and skeletal collection sub-samples differences, as well as age at death correlations. These will be tested between, and within all the mentioned variables (DBC, OA, MSM and DMSM).

6.1 Degenerative bony changes (DBC) to the joints

6.1.1 Degenerative Bony Changes (DBC) analysis

6.1.1.1 DBC summary statistics: frequency and percentages per articular surfaces

Marginal lipping was the most frequent degenerative bone lesion found in all joint surfaces observed, followed by porosity and osteophytes (Tables 14 to 20). The high frequency of marginal lipping was due to the high number of cases classified as "barely discernible". Eburnation was the DBC with the lowest frequency, often only one case being recorded per articular surface, such was the case of the proximal end of the right ulna (Table 16) and left *acetabulum* (Table 18). Other cases of eburnation were observed, but these were excluded from the analysis because they represented secondary manifestation of DBC due to traumatic events (Figure 36). Fully detail descriptive statistics of the DBC observed per articular surface, according to the total sample, sex and collections sub-samples can be consulted in Appendix_DBC (Tables 3 and 4).

Table 14 - Frequency and percentages of degenerative bone changes in the shoulder joint.

	Shoulder joint			
	Glenoid cavity		Humeral head	
Bony change	Left % (n*/N**)	Right % (n*/N**)	Left % (n*/N**)	Right % (n*/N**)
Marginal lipping	61.8% (362/586)	60.8% (354/582)	41.1% (236/574)	45.4% (262/577)
Porosity	13% (76/586)	9.6% (56/582)	8.8% (51/579)	6.2% (36/578)
Osteophytes	8% (47/586)	6.9% (40/582)	4.8% (28/579)	3.8% (22/578)
Eburnation	0.6% (4/586)	0.5% (3/582)	1% (6/579)	0.9% (5/578)

*number of cases with lesion; **total number of cases where observation was possible

Table 15 - Frequency and percentages of degenerative bone changes in the shoulder joint (scapula – clavicle articulation).

	Shoulder joint			
	Scapula: acromion articular surface		Clavicle: acromion articular surface	
Bony change	Left % (n*/N**)	Right % (n*/N**)	Left % (n*/N**)	Right % (n*/N**)
Marginal lipping	28.3% (139/491)	35.1% (171/487)	27.98% (131/469)	28.3% (134/475)
Porosity	30.5% (150/491)	34.1% (166/487)	52.6% (247/470)	55.5% (265/476)
Osteophytes	0.8% (4/491)	1.4% (7/487)	2.8% (13/470)	3.4% (16/476)
Eburnation	3.1% (15/491)	4.1% (20/487)	2.6% (12/470)	3.8% (18/476)

*number of cases with lesion; **total number of cases where observation was possible

Table 16 - Frequency and percentages of degenerative bone changes in the elbow joint.

	Elbow joint					
	Humerus distal end		Radius proximal end		Ulna proximal end	
Bony change	Left % (n*/N**)	Right % (n*/N**)	Left % (n*/N**)	Right % (n*/N**)	Left % (n*/N**)	Right % (n*/N**)
Marginal lipping	33.3% (188/565)	41% (233/568)	16.4% (90/549)	17.6% (94/534)	43.8% (252/576)	50% (290/580)
Porosity	15.1% (87/576)	14.8% (85/575)	7.3% (42/573)	7.4% (41/557)	7.2% (42/584)	7.2% (42/583)
Osteophytes	10.4% (60/576)	12.2% (70/575)	5.9% (34/573)	7.2% (40/557)	3.5% (21/584)	3.4% (20/583)
Eburnation	3.3% (19/576)	2.3% (13/575)	3% (17/573)	2.3% (13/557)	0.5% (3/584)	0.2% (1/583)

*number of cases with lesion; **total number of cases where observation was possible

Table 17 - Frequency and percentages of degenerative bone changes in the wrist joint.

	Wrist joint			
	Radius distal end		Ulna distal end	
Bony change	Left % (n*/N**)	Right % (n*/N**)	Left % (n*/N**)	Right % (n*/N**)
Marginal lipping	28.1% (160/570)	28.6% (163/570)	15.8% (84/533)	23.6% (127/539)
Porosity	2.6% (15/575)	2.6% (15/572)	5.4% (29/534)	5% (27/541)
Osteophytes	1% (6/575)	0.9% (5/572)	2.8% (15/534)	4.1% (22/541)
Eburnation	0.9% (5/575)	1.2% (7/572)	2.1%(11/534)	2.6% (14/541)

*number of cases with lesion; **total number of cases where observation was possible

Table 18 - Frequency and percentages of degenerative bone changes in the hip joint.

Bony change	Hip joint			
	Acetabulum		Femoral head	
	Left	Right	Left	Right
	% (n*/N**)	% (n*/N**)	% (n*/N**)	% (n*/N**)
Marginal lipping	85.6% (506/591)	87.2% (520/596)	55.3% (326/589)	59% (348/590)
Porosity	28.6% (169/591)	30.9% (184/595)	19.3% (115/595)	20% (119/596)
Osteophytes	9.6% (57/591)	11.8% (71/596)	15.5% (92/595)	16.3% (97/596)
Eburnation	0.2% (1/591)	1.5% (9/596)	0.5% (3/595)	1.2% (7/596)

*number of cases with lesion; **total number of cases where observation was possible

Table 19 - Frequency and percentages of degenerative bone changes in the knee joint.

Bony change	Knee joint					
	Patella		Femur distal end		Tibia proximal end	
	Left	Right	Left	Right	Left	Right
	% (n*/N**)	% (n*/N**)	% (n*/N**)	% (n*/N**)	% (n*/N**)	% (n*/N**)
Marginal lipping	53.8% (290/539)	54.2% (287/530)	49.7% (296/595)	53.9% (321/595)	39.3% (231/588)	39.7% (234/590)
Porosity	13.4% (73/543)	12.6% (67/531)	14.9% (89/596)	15.4% (92/598)	6.6% (39/595)	7% (42/598)
Osteophytes	11.2% (61/543)	11.1% (59/531)	15.9% (95/596)	17.2% (103/598)	5% (30/595)	6.4% (38/598)
Eburnation	2.4% (13/543)	3.6% (19/531)	3.2% (19/596)	5.4% (32/598)	1% (6/596)	2% (12/598)

*number of cases with lesion; **total number of cases where observation was possible

Table 20 - Frequency and percentages of degenerative bone changes in the ankle joint

Bony change	Ankle joint			
	Tibia distal end		Fibula distal end	
	Left	Right	Left	Right
	% (n*/N**)	% (n*/N**)	% (n*/N**)	% (n*/N**)
Marginal lipping	29% (173/596)	35.7% (212/594)	5.5% (32/582)	5% (29/581)
Porosity	1.3% (8/599)	2.5% (15/596)	0.7% (4/582)	1% (6/582)
Osteophytes	0.8% (5/599)	2.3% (14/596)	0.5% (3/582)	0.7% (4/582)
Eburnation	0.3% (2/599)	-	-	-

*number of cases with lesion; **total number of cases where observation was possible

Figure 36 –Example of DBC related to secondary O.A.: present extensive spicule formation (marginal lipping), porosity, eburnation and severe subchondral destruction. An orthopaedic pin is also visible. These lesions were observed in a woman born in Lisbon in 1884. She died in 1954 at 70 years. Her occupation was that of *doméstica*.

Bilateral asymmetry was tested for all features analysed using the Wilcoxon signed rank test. Statistical significance was found on the following variables: marginal lipping and porosity on the scapula acromion surface ($p \leq 0.007$), porosity on the glenoid cavity ($p=0.003$), marginal lipping on the humerus distal end ($p=0.029$), ulna proximal end ($p=0.001$), ulna distal end ($p<0.001$), femur proximal ($p=0.004$) and distal ends ($p=0.006$), eburnation on the femur distal end ($p=0.028$), and tibia proximal end ($p=0.032$), marginal lipping on the tibia distal end ($p<0.001$) and *patella* ($p=0.049$), and finally eburnation on the *acetabulum* ($p=0.025$). A few cases of marginal statistical significance were also encountered: porosity on the humerus head ($p=0.056$) and osteophytes on the *acetabulum* ($p=0.055$). With the exception of porosity on the glenoid cavity, all variables presented a higher severity degree on the right side (Table 21).

Table 21 - Wilcoxon signed rank test results: bilateral asymmetry of degenerative bony changer per articular surface observed.

			Bony change							
			Marginal lipping		Porosity		Osteophytes		Eburnation	
	Bone	Articular surface	Z	p	Z	p	Z	p	Z	p
Shoulder	Clavicle	Acromion	-1.424	0.157	-1.651	0.102	-1.148	0.289	-1.212	0.274
	Scapula	Acromion	-4.056	**<0.001**	-2.662	**0.007**	-0.632	0.768	-0.634	0.561
	Scapula	Glenoid cavity	-1.020	0.314	-2.980	**0.003**	-0.891	0.397	-0.351	0.842
	Humerus	Humeral head	-1.919	0.062	-1.960	0.056	-1.682	0.107	-0.187	1.000
Elbow	Humerus	Distal end	-2.212	**0.029**	-0.780	0.441	-1.501	0.135	-1.797	0.073
	Radius	Proximal end	-0.270	0.788	-0.603	0.552	-1.420	0.167	-0.920	0.369
	Ulna	Proximal end	-3.453	**0.001**	-0.742	0.477	-0.737	0.500	-1.512	0.248
Wrist	Radius	Distal end	-0.375	0.696	-0.760	0.486	-0.359	0.821	-0.520	0.654
	Ulna	Distal end	-3.867	**<0.001**	-1.080	0.292	-0.485	0.680	-0.662	0.523
Hip	Coxal	*Acetabulum*	-0.794	0.388	-1.362	0.180	-1.963	0.055	-2.339	**0.025**
	Femur	Proximal end	-2.875	**0.004**	-0.732	0.458	-0.901	0.385	-1.324	0.211
Knee	Femur	Distal end	-2.743	**0.006**	-0.213	0.840	-0.866	0.406	-2.212	**0.028**
	Tibia	Proximal end	-1.643	0.109	-0.804	0.439	-1.698	0.102	-2.265	**0.032**
	Patella		-1.941	**0.049**	-0.313	0.766	-0.418	0.704	-1.651	0.113
Ankle	Tibia	Distal end	-4.128	**<0.001**	-1.560	0.134	-1.818	0.082	-1.414	0.505
	Fibula	Distal end	-0.493	0.750	-1.000	0.533				

Bold p-values represent statistical significant values (according to the Monte Carlo significance test, 2-tailed).

6.1.1.2 DBC: analysis by sex of the individuals

The following tables contain the frequencies, and percent values, of the DBC observed according to the sex of the individuals. Overall, the frequency of women exhibiting bony changes was higher than for men (Tables 22 to 27). The shaded areas correspond to cases were a statistical significant difference, between male and females individuals, was found.

Table 22 – Frequency and percentages of degenerative bone changes in the shoulder joint according to sex of the individuals.

Clavicle: acromion surface	Left				Right			
	Marginal lipping	Porosity	Osteophytes	Eburnation	Marginal lipping	Porosity	Osteophytes	Eburnation
Female	81	127	7	8	71	123	10	9
	61.8%	51.4%	53.8%	66.7%	53%	46.8%	62.5%	50%
Male	50	120	6	4	63	140	6	9
	38.2%	48.6%	46.2%	33.3%	47%	53.2%	37.5%	50%
Total	131	247	13	12	134	263	16	18
Scapula: acromion surface								
Female	75	69	3	9	90	76	6	10
	54%	46%	75%	60%	52.6%	45.8%	85.7%	50%
Male	64	81	1	6	81	90	1	10
	46%	54%	25%	40%	47.4%	54.2%	14.3%	50%
Total	139	150	4	15	171	166	7	20
Glenoid cavity								
Female	189	48	28	3	182	31	19	3
	52.20%	63.20%	59.60%	75.00%	51.40%	55.40%	47.50%	100.00%
Male	173	28	19	1	172	25	21	
	47.80%	36.80%	40.40%	25.00%	48.60%	44.60%	52.50%	-
Total	362	76	47	4	354	56	40	3
Humerus proximal end								
Female	136	34	16	6	150	21	12	4
	57.60%	66.70%	57.10%	100.00%	57.30%	58.30%	54.50%	80.00%
Male	100	17	12		112	15	10	1
	42.40%	33.30%	42.90%	-	42.70%	41.70%	45.50%	20.00%
Total	236	51	28	6	262	36	22	5

Shaded areas represent cases of statistical significance according to Mann-Whitney statistical test (see appropriate table). The Total values refer to cases were a positive observation of the lesions was achieved.

Table 23 - Frequency and percentages of degenerative bone changes in the elbow joint according to sex of the individuals.

Humerus distal end	Left				Right			
	Marginal lipping	Porosity	Osteophytes	Eburnation	Marginal lipping	Porosity	Osteophytes	Eburnation
Female	104	48	34	13	130	48	37	10
	55.30%	55.20%	56.70%	68.40%	55.80%	56.50%	52.90%	76.90%
Male	84	39	26	6	103	37	33	3
	44.70%	44.80%	43.30%	31.60%	44.20%	43.50%	47.10%	23.10%
Total	188	87	60	19	233	85	70	13
Radius proximal end								
Female	54	30	18	12	56	28	20	11
	60.00%	71.40%	52.90%	70.60%	59.60%	68.30%	50.00%	84.60%
Male	36	12	16	5	38	13	20	2
	40.00%	28.60%	47.10%	29.40%	40.40%	31.70%	50.00%	15.40%
Total	90	42	34	17	94	41	40	13
Ulna proximal end								
Female	132	28	14	3	148	30	14	1
	52.40%	66.70%	66.70%	100.00%	51.00%	71.40%	70.00%	100.00%
Male	120	14	7		142	12	6	
	47.60%	33.30%	33.30%	-	49.00%	28.60%	30.00%	-
Total	252	42	21	3	290	42	20	1

Shaded areas represent cases of statistical significance according to Mann-Whitney statistical test (see appropriate table). The Total values refer to cases were a positive observation of the lesions was achieved.

Table 24 - Frequency and percentages of degenerative bone changes in the wrist joint according to sex of the individuals.

Radius distal end	Left				Right			
	Marginal lipping	Porosity	Osteophytes	Eburnation	Marginal lipping	Porosity	Osteophytes	Eburnation
Female	83	8	5	1	88	9	2	2
	51.90%	53.30%	83.30%	20.00%	54.00%	60.00%	40.00%	28.60%
Male	77	7	1	4	75	6	3	5
	48.10%	46.70%	16.70%	80.00%	46.00%	40.00%	60.00%	71.40%
Total	160	15	6	5	163	15	5	7
Ulna distal end								
Female	40	9	6	7	63	14	7	7
	47.60%	31.00%	40.00%	63.60%	49.60%	51.90%	31.80%	50.00%
Male	44	20	9	4	64	13	15	7
	52.40%	69.00%	60.00%	36.40%	50.40%	48.10%	68.20%	50.00%
Total	84	29	15	11	127	27	22	14

Shaded areas represent cases of statistical significance according to Mann-Whitney statistical test (see appropriate table). The Total values refer to cases were a positive observation of the lesions was achieved.

Table 25 - Frequency and percentages of degenerative bone changes in the hip joint according to sex of the individuals.

Acetabulum	Left				Right			
	Marginal lipping	Porosity	Osteophytes	Eburnation	Marginal lipping	Porosity	Osteophytes	Eburnation
Female	259	83	18	1	263	95	25	4
	51.20%	49.10%	31.60%	100.00%	50.60%	51.60%	35.20%	44.40%
Male	247	86	39		257	89	46	5
	48.80%	50.90%	68.40%	-	49.40%	48.40%	64.80%	55.60%
Total	506	169	57	1	520	184	71	9
Femur proximal end								
Female	173	63	42	3	180	60	43	4
	53.10%	54.80%	45.70%	100.00%	51.70%	50.40%	44.30%	57.10%
Male	153	52	50		168	59	54	3
	46.90%	45.20%	54.30%	-	48.30%	49.60%	55.70%	42.90%
Total	326	115	92	3	348	119	97	7

Shaded areas represent cases of statistical significance according to Mann-Whitney statistical test (see appropriate table). The Total values refer to cases were a positive observation of the lesions was achieved.

Table 26 - Frequency and percentages of degenerative bone changes in the knee joint according to sex of the individuals.

Femur distal end	Left				Right			
	Marginal lipping	Porosity	Osteophytes	Eburnation	Marginal lipping	Porosity	Osteophytes	Eburnation
Female	162	48	65	14	179	56	70	23
	54.70%	53.90%	68.40%	73.70%	55.80%	60.90%	68.00%	71.90%
Male	134	41	30	5	142	36	33	9
	45.30%	46.10%	31.60%	26.30%	44.20%	39.10%	32.00%	28.10%
Total	296	89	95	19	321	92	103	32
Tibia proximal end								
Female	132	23	17	6	130	23	23	9
	57.10%	59.00%	56.70%	100.00%	55.60%	54.80%	60.50%	75.00%
Male	99	16	13		104	19	15	3
	42.90%	41.00%	43.30%	-	44.40%	45.20%	39.50%	25.00%
Total	231	39	30	6	234	42	38	12
Patella								
Female	157	51	42	9	160	46	39	16
	54.10%	69.90%	68.90%	69.20%	55.70%	68.70%	66.10%	84.20%
Male	133	22	19	4	127	21	20	3
	45.90%	30.10%	31.10%	30.80%	44.30%	31.30%	33.90%	15.80%
Total	290	73	61	13	287	67	59	19

Shaded areas represent cases of statistical significance according to Mann-Whitney statistical test (see appropriate table). The Total values refer to cases were a positive observation of the lesions was achieved.

Table 27 - Frequency and percentages of degenerative bone changes in the ankle joint according to sex of the individuals.

Tibia distal end	Left				Right			
	Marginal lipping	Porosity	Osteophytes	Eburnation	Marginal lipping	Porosity	Osteophytes	Eburnation
Female	85 49.10%	4 50.00%	2 40.00%	2 100.00%	98 46.20%	3 20.00%	4 28.60%	-
Male	88 50.90%	4 50.00%	3 60.00%	-	114 53.80%	12 80.00%	10 71.40%	-
Total	173	8	5	2	212	15	14	-
Fibula distal end								
Female	12 37.50%	2 50.00%	2 66.70%	-	12 41.40%	2 33.30%	2 50.00%	-
Male	20 62.50%	2 50.00%	1 33.30%	-	17 58.60%	4 66.70%	2 50.00%	-
Total	32	4	3	-	29	6	4	-

Shaded areas represent cases of statistical significance according to Mann-Whitney statistical test (see appropriate table). The Total values refer to cases were a positive observation of the lesions was achieved.

The Mann-Whitney test results can be consulted in Table 28. Significant differences were found on the shoulder, elbow and knee joints affecting mostly marginal lipping and osteophytes. Almost in all statistical significant cases women's mean severity of lesion was higher than the one found in men. The contrary was only observed with porosity on the clavicle acromion surface, porosity on the proximal end of the left ulna and osteophytes on both right and left *acetabulum.* There were a few cases of borderline statistical significance: porosity on the left ulna distal end (p=0.057), eburnation on the left radius proximal end (p=0.061), osteophytes on the acromion surface of the right scapula (p=0.057) and osteophtyes on the right ulna proximal end (p=0.062) Table 28. With exception of the first case, with a male having higher values of lesions, in the remaining cases women exhibited more severe lesions. The absence of results on osteophytes or eburnation severity was due to the small number of cases per category of bony change (see Table 14 to 20).

Apart from the analysis of degrees of lesions, DBC were also tested according with the Presence/Absence of the lesions (all grades included). The Chi-square statistical test used to assess the associations between the dichotomous variables and sex revealed similar results to the ones obtained with the ordinal variables. Exceptions were found for eburnation on the distal end of right humerus (p=0.053) and left femur (p=0.060), marginal lipping on the proximal end of left radius (p=0.053) and left tibia (p=0.053). The previous statistical significance achieved using the ordinal variable (degree of lesions), was revealed to be only marginally significant when the dichotomous variables were used (Table 5; Appendix_DBC). However, when found, the statistical significance continued to associate women and lesion: that is, women were more likely to have any DBC than men.

Bilateral asymmetry testing detected a clear right side dominance of lesions for both females and males. The only sites where a left dominance was detected were on the female glenoid cavity (posority, $p<0.001$) and female humerus distal end (marginal lipping, $p=0.038$). There were also found a few cases of marginal significance: females, marginal lipping of the femur distal end $p=0.05$); males, marginal lipping on the femur proximal end ($p=0.062$), femur distal end ($p=0.053$), and porosity on the ulna distal end ($p=0.069$) (Table 6; Appendix_DBC).

Table 28 - Mann-Whitney test results: assessment of the severity of degenerative bony changes according to the sex of individuals.

Left side

Joint	Bone	Articular surface	Marginal lipping U	Marginal lipping Z	Marginal lipping p	Porosity U	Porosity Z	Porosity p	Osteophytes U	Osteophytes Z	Osteophytes p	Eburnation U	Eburnation Z	Eburnation p
Shoulder	Clavicle	Acromion	24469.5	-2.544	0.010	26288.5	-0.915	0.356	27499.5	-0.068	0.981	27134.0	-0.981	0.331
	Scapula	Acromion	28790.5	-1.074	0.287	28347.0	-1.394	0.161	29888.5	-0.966	0.629	29793.0	-0.709	0.573
	Scapula	Glenoid cavity	40501.5	-1.253	0.211	39872.5	-2.550	0.011	41696.5	-1.268	0.218			
	Humerus	Humeral head	36181.0	-2.870	0.004	39420.0	-2.511	0.012	41354.0	-0.733	0.511			
Elbow	Humerus	Distal end	37149.0	-1.710	0.088	40204.0	-1.014	0.311	40410.0	-0.996	0.311	40480.5	-1.592	0.110
	Radius	Proximal end	34969.5	-2.261	0.024	38391.5	-2.959	0.002	40730.0	-0.382	0.690	40020.5	-1.751	0.061
	Ulna	Proximal end	38409.0	-1.718	0.085	40571.5	-2.257	0.023	41603.0	-1.565	0.117			
Wrist	Radius	Distal end	39378.5	-0.789	0.428	41133.0	-0.336	0.642						
	Ulna	Distal end	35243.5	-0.219	0.833	34292.0	-1.907	0.057	35275.5	-0.688	0.588	35190.0	-0.995	0.271
Hip	Coxal	*Acetabulum*	41903.0	-0.908	0.365	42780.0	-0.530	0.598	40493.5	-2.976	0.003			
	Femur	Proximal end	40983.0	-1.254	0.210	42789.5	-1.015	0.311	42753.0	-1.138	0.252			
Knee	Femur	Distal end	37337.5	-3.606	0.000	43220.0	-0.907	0.366	39232.5	-3.868	<0.001	43071.0	-2.078	0.042
	Tibia	Proximal end	37022.0	-3.447	0.001	43196.0	-1.175	0.236	43667.5	-0.735	0.505			
	Patella		31720.5	-2.742	0.006	32796.0	-3.748	<0.001	33713.5	-3.140	0.002	36160.5	-1.435	0.102
Ankle	Tibia	Distal end	43921.0	-0.289	0.777									
	Fibula	Distal end	41154.0	-1.481	0.133									

Right side

Joint	Bone	Articular surface	Marginal lipping U	Marginal lipping Z	Marginal lipping p	Porosity U	Porosity Z	Porosity p	Osteophytes U	Osteophytes Z	Osteophytes p	Eburnation U	Eburnation Z	Eburnation p
Shoulder	Clavicle	Acromion	27416.5	-0.665	0.495	25273.5	-2.188	0.027	27852.0	-0.999	0.356	28302.0	-0.036	0.944
	Scapula	Acromion	27774.5	-1.419	0.155	28083.5	-1.198	0.237	29018.5	-1.942	0.057	29620.0	-0.037	0.995
	Scapula	Glenoid cavity	41614.0	-0.379	0.709	41493.0	-0.815	0.422	41905.0	-1.723	0.249			
	Humerus	Humeral head	35412.5	-3.476	<0.001	40844.5	-1.087	0.251	41453.5	-0.458	0.642			
Elbow	Humerus	Distal end	36000.5	-2.544	0.011	39493.5	-1.491	0.135	40694.0	-0.558	0.592	40305.0	-1.989	0.045
	Radius	Proximal end	33226.5	-2.047	0.041	36628.5	-2.503	0.010	38760.0	-0.024	0.979	37524.0	-2.529	0.012
	Ulna	Proximal end	39945.0	-1.138	0.257	39801.0	-2.945	0.002	41304.0	-1.842	0.062			
Wrist	Radius	Distal end	39059.0	-1.001	0.317	40476.0	-0.771	0.560						
	Ulna	Distal end	36133.5	-0.115	0.909	36311.0	-0.369	0.701	35551.5	-1.628	0.110	36519.0	-0.090	0.905
Hip	Coxal	*Acetabulum*	41730.5	-1.372	0.170	43646.0	-0.353	0.725	41124.0	-2.772	0.006			
	Femur	Proximal end	40941.0	-1.339	0.181	44153.0	-0.170	0.868	42691.5	-1.269	0.209			
Knee	Femur	Distal end	36437.0	-4.023	<0.001	41564.0	-2.368	0.018	39154.5	-4.002	<0.001	42633.0	-2.509	0.015
	Tibia	Proximal end	39012.0	-2.479	0.013	44100.0	-0.640	0.531	43562.0	-1.273	0.233	43815.0	-1.722	0.142
	Patella		29886.0	-3.190	0.001	31788.0	-3.391	0.001	32699.5	-2.641	0.008	33510.0	-3.049	0.002
Ankle	Tibia	Distal end	41856.5	-1.279	0.208	43057.5	-2.358	0.015	43511.0	-1.616	0.159			
	Fibula	Distal end	41464.0	-0.958	0.366									

Shaded p-values represent statistical significant values (according to the Monte Carlo significance test, 2-tailed). The absence of values represent cases were the test was not performed due to the small number of cases.

6.1.1.3 DBC: analysis according to skeletal collection

According to the Mann-Whitney statistical test, there were significant differences between the degrees of DBC and skeletal collections. Major differences were found on marginal lipping, porosity and osteophytes particularly on the right side articular facets. The Coimbra Identified Skeletal Collection (CISC) had the higher mean scores recorded in all cases, that is, the degree of lesions were more severe in that collection that in the Luis Lopes Skeletal Collection (LLSC) (Table 29; see Table 4 in Appendix_DBC for descriptive statistics).

6.1.1.4 DBC: analysis according to age at death

Statistically significant results were found between age at death and degrees of severity of DBC throughout all the articular surfaces analysed (Table 30). Major age differences were found between the mean ages of individuals without lesions, and the ones with lesions. On average, individuals with lesion were significantly older than individuals without DBC. There are some exceptions in which older individuals exhibit no lesions, and young individuals showed signs of DBC, but these were rare cases representing outliers to the overall distribution pattern of DBC.

Descriptive statistics of the number of individuals affected with lesions, mean age per group and age range of each group can be consulted in the Appendix_DBC (Tables 7-13). The Kendall's tau_b correlation statistical test corroborated the presence of a positive relationship between age and the lesions analysed, as illustrated by the scatterplot (Figure 37). However, the strength of the correlation varies from moderate to low in the majority of the DBC. Strong effects ($r>0.6$) were only found in the cases of marginal lipping. The higher values of correlation were found on both left ($r=0.654$) and right ($r=0.649$) *acetabuli* (Table 31).

Table 29 — Mann-Whitney test results: assessment of DBC differences between collections

Left side

Joint	Bone	Articular surfa	Marginal lipping U	Marginal lipping Z	Marginal lipping p	Porosity U	Porosity Z	Porosity p	Osteophytes U	Osteophytes Z	Osteophytes p	Eburnation U	Eburnation Z	Eburnation p
[illegible]	Clavicle	Acromion	25480.0	-1.644	0.101	25995.5	-1.099	0.278	26796.0	-1.650	0.154	27346.0	-0.345	0.724
	Scapula	Acromion	28665.0	-1.176	0.245	25825.0	-3.371	0.001	29643.0	-1.970	0.127	29724.0	-0.856	0.391
	Scapula	Glenoid cavity	32528.5	-5.384	<0.001	42819.0	-0.085	0.938	41077.0	-1.911	0.062			
	Humerus	Humeral head	31956.5	-5.292	<0.001	40021.5	-1.904	0.060	38996.0	-3.887	<0.001			
Elbow	Humerus	Distal end	36322.0	-2.202	0.026	35521.5	-4.784	<0.001	38909.5	-2.417	0.014	40720.0	-1.210	0.213
	Radius	Proximal end	35631.0	-1.634	0.106	39446.0	-1.771	0.076	40067.0	-1.189	0.240	40286.5	-1.279	0.222
	Ulna	Proximal end	30762.5	-5.997	<0.001	40471.0	-2.362	0.015	40412.0	-3.370	0.001			
Wrist	Radius	Distal end	40210.5	-0.240	0.811	40843.5	-0.854	0.418						
	Ulna	Distal end	34137.5	-1.070	0.283	35044.0	-0.601	0.490	34934.0	-1.041	0.361	35236.5	-0.520	0.759
Hip	Coxal	*Acetabulum*	31837.0	-6.127	<0.001	39231.5	-2.684	0.008	38591.0	-4.772	<0.001			
	Femur	Proximal end	29148.5	-7.484	<0.001	33592.5	-7.398	<0.001	36151.0	-6.152	<0.001			
Knee	Femur	Distal end	31329.5	-6.739	<0.001	39459.0	-3.798	<0.001	37129.0	-5.444	<0.001	42773.0	-2.546	0.015
	Tibia	Proximal end	29196.5	-7.802	<0.001	40902.0	-3.721	<0.001	41628.0	-3.295	0.001			
	Patella		25459.5	-6.392	<0.001	31928.0	-4.418	<0.001	32494.0	-4.216	<0.001	36455.0	-0.513	0.726
Ankle	Tibia	Distal end	37476.0	-4.172	<0.001									
	Fibula	Distal end	41098.5	-1.541	0.127									

Right side

Joint	Bone	Articular surfa	Marginal lipping U	Marginal lipping Z	Marginal lipping p	Porosity U	Porosity Z	Porosity p	Osteophytes U	Osteophytes Z	Osteophytes p	Eburnation U	Eburnation Z	Eburnation p
[illegible]	Clavicle	Acromion		-2.399	0.017	23978.0	-3.112	0.001	27793.5	-1.102	0.279	27881.5	-0.863	0.453
	Scapula	Acromion		-2.316	0.020	26799.5	-2.186	0.026	29265.0	-1.172	0.279	28869.0	-1.444	0.142
	Scapula	Glenoid cavity		-5.374	<0.001	42052.5	-0.273	0.783	38916.0	-3.846	<0.001			
	Humerus	Humeral head		-3.329	0.001	40633.5	-1.341	0.219	40040.5	-2.585	0.013			
Elbow	Humerus	Distal end		-2.769	0.006	36671.0	-3.786	<0.001	37676.0	-3.227	0.001	40862.0	-0.897	0.304
	Radius	Proximal end		-1.329	0.187	37043.5	-1.970	0.051	36296.0	-2.873	0.005	37978.5	-1.526	0.145
	Ulna	Proximal end		-6.684	<0.001	40290.5	-2.406	0.017	40719.0	-2.751	0.006			
Wrist	Radius	Distal end		-1.607	0.109	40196.0	-1.275	0.237						
	Ulna	Distal end		-0.579	0.563	35986.0	-0.742	0.464	36388.0	-0.171	0.992	36424.0	-0.140	1.000
Hip	Coxal	*Acetabulum*		-6.386	<0.001	38498.0	-3.363	0.001	38734.0	-4.796	<0.001			
	Femur	Proximal end		-7.108	<0.001	36556.0	-5.361	<0.001	37411.0	-5.185	<0.001			
Knee	Femur	Distal end		-6.884	<0.001	40193.5	-3.402	0.001	38172.5	-4.710	<0.001	43260.5	-1.746	0.103
	Tibia	Proximal end		-8.007	<0.001	41190.5	-3.748	<0.001	41172.5	-3.946	<0.001			
	Patella			-6.969	<0.001	32003.5	-2.964	0.003	30215.0	-4.997	<0.001	34160.0	-1.506	0.158
Ankle	Tibia	Distal end		-4.103	<0.001	44243.5	-0.277	0.684	42909.5	-2.706	0.008			
	Fibula	Distal end		-1.034	0.320									

Shaded p values represent statistical significant values (according to the Monte Carlo significance test, 2-tailed). The absence of values represent cases were the test was not performed due to the small number of cases (number of cases per severity degree was less than 10).

Table 30 - Jonckheere-Trepstra test results: differences between age and the degree of degenerative bony changes

			Left								Right							
			Marginal lipping		Porosity		Osteophytes		Eburnation		Marginal lipping		Porosity		Osteophytes		Eburnation	
		Articular surface	J	p	J	p	J	p	J	p	J	p	J	p	J	p	J	p
Shoulder	Clavicle	Acromion	37776.5	<0.001	53344.0	<0.001	4476.0	0.002	3974.0	0.008	38931.0	<0.001	57337.0	<0.001	5953.0	<0.001	6004.0	0.001
	Scapula	Acromion	41521.5	<0.001	45882.0	<0.001	1548.5	0.039	5178.5	0.003	48554.0	<0.001	47141.0	<0.001	2431.5	0.042	6672.0	0.002
	Scapula	Glenoid cavity	96186.0	<0.001	28130.5	<0.001	19216.5	<0.001	-	-	95023.0	<0.001	13953.0	0.002	17641.5	<0.001	-	-
	Humerus	Humerus proximal end	71829.5	<0.001	20015.0	<0.001	12649.0	<0.001	-	-	77961.0	<0.001	1499.0	<0.001	10596.5	<0.001	-	-
Elbow	Humerus	Humerus distal end	57881.0	<0.001	32525.0	<0.001	24542.0	<0.001	8447.0	<0.001	65596.5	<0.001	33561.5	<0.001	28660.0	<0.001	6226.5	<0.001
	Radius	Radius proximal end	31339.0	<0.001	18855.0	<0.001	14482.0	<0.001	7455.0		33804.5	<0.001	17894.0	<0.001	17053.5	<0.001	6221.0	<0.001
	Ulna	Ulna proximal end	74008.0	<0.001	17364.5	<0.001	8788.0	<0.001	-	-	82028.5	<0.001	18603.5	<0.001	8581.5	<0.001	-	-
Wrist	Radius	Radius distal end	52192.0	<0.001	6293.5	0.001	-	-	-	-	53629.5	<0.001	6568.0	<0.001	-	-	-	-
	Ulna	Ulna distal end	31366.5	<0.001	10801.0	<0.001	5918.0	<0.001	4810.5	<0.001	42679.0	<0.001	11428.5	<0.001	9156.0	<0.001	6014.5	<0.001
Hip	Coxal	*Acetabulum*	94820.5	<0.001	58508.0	<0.001	23732.0	<0.001	-	-	94721.0	<0.001	64625.5	<0.001	30189.0	<0.001	-	-
	Femur	Femur proximal end	84557.5	<0.001	40210.0	<0.001	35021.5	<0.001	-	-	87063.5	<0.001	40173.5	<0.001	37150.5	<0.001	-	-
Knee	Femur	Femur distal end	82883.0	<0.001	36344.0	<0.001	39773.0	<0.001	9169.0	<0.001	86021.0	<0.001	38162.5	<0.001	42378.0	<0.001	15673.0	<0.001
	Tibia	Tibia proximal end	75130.0	<0.001	17863.0	<0.001	13968.0	<0.001	-	-	75439.0	<0.001	18271.0	<0.001	16806.5	<0.001	-	-
	Patella	*Patella*	72925.0	<0.001	29019.0	<0.001	52007.5	<0.001	5200.5	0.002	72996.5	<0.001	25843.5	<0.001	23292.0	<0.001	8183.0	<0.001
Ankle	Tibia	Distal end	53178.5	<0.001	-	-	-	-	-	-	60458.0	<0.001	5464.5	0.107	5121.5	0.108	-	
	Fibula	Distal end	12420.5	<0.001	-	-	-	-	-	-	11920.0	<0.001	-	-	-	-	-	

Two-tailed, 0.05 level of significance was calculated using Monte Carlo statistics.

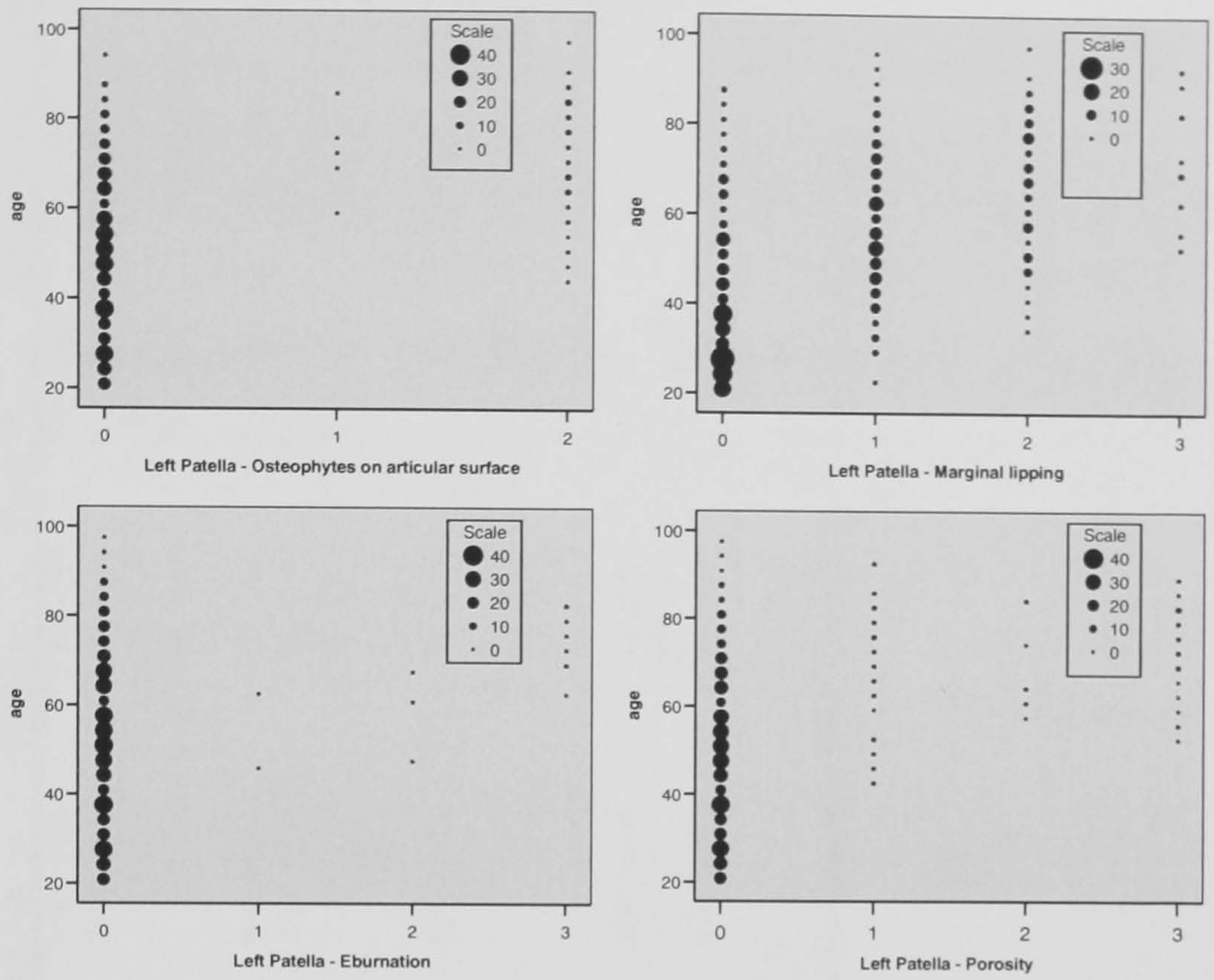

Figure 37 – Scatterplot of DBC distribution according to age at death.

As illustrated in the Figure the more severe degrees of DBC were found in older individuals. There are also cases of aged individuals were no DBC were found, as well as young individuals where grade 1 lesions could be found, these last two patterns represented "abnormal" cases/outliers, and were rare.

6.1.1.5 DBC: summary of results

As explained at the start of this section, the hierarchy of frequency of DBC was the following: marginal lipping, porosity, osteophytes and finally eburnation, with slight variation between the frequencies of osteophytes and eburnation. In general, the degree of severity was higher in the right side articular surfaces, independently of the site of the facet or the DBC under observation. Degenerative bony changes were found to be more severe in the CISC. These lesions were also more frequent in women, than in men, and generally possessed a strong and significant association with age.

Table 31 - Kendall's tau_b test results: correlation between DBC and age at death.

			Left								Right							
			Marginal lipping		Porosity		Osteophytes		Eburnation		Marginal lipping		Porosity		Osteophytes		Eburnation	
		Articular surface	Kendall's tau_b	p	Kendall's tau_b	p	Kendall's tau_b	p	Kendall's tau_b	p	Kendall's tau_b	p	Kendall's tau_b	p	Kendall's tau_b	p	Kendall's tau_b	p
Shoulder	Clavicle	Acromion	0.373	<0.001	0.424	<0.001	0.117	0.002	0.099	0.009	0.368	<0.001	0.465	<0.001	0.156	<0.001	0.121	0.001
	Scapula	Acromion	0.372	<0.001	0.419	<0.001	0.76	0.042*	0.109	0.003	0.412	<0.001	0.417	<0.001	0.076	0.043*	0.118	0.002
	Scapula	Glenoid cavity	0.544	<0.001	0.196	<0.001	0.193	<0.001	-	-	0.545	<0.001	0.150	<0.001	0.219	<0.001	-	-
	Humerus	Humeurs proximal end	0.427	<0.001	0.189	<0.001	0.191	<0.001	-	-	0.484	<0.001	0.181	<0.001	0.196	<0.001	-	-
Elbow	**Humerus**	Humeurs distal end	0.347	<0.001	0.239	<0.001	0.239	<0.001	0.149	<0.001	0.384	<0.001	0.279	<0.001	0.272	<0.001	0.147	<0.001
	Radius	Radius proximal end	0.239	<0.001	0.248	<0.001	0.189	<0.001	0.137	<0.001	0.306	<0.001	0.247	<0.001	0.230	<0.001	0.161	<0.001
	Ulna	Ulna proximal end	0.485	<0.001	0.203	<0.001	0.154	<0.001	-	-	0.543	<0.001	0.255	<0.001	0.150	<0.001	-	-
Wrist	Radius	Radius distal end	0.332	<0.001	0.112	<0.001	-	-	-	-	0.348	<0.001	0.129	<0.001				
	Ulna	Ulna distal end	0.358	<0.001	0.180	<0.001	0.146	<0.001	0.183	<0.001	0.378	<0.001	0.241	<0.001	0.194	<0.001	0.161	<0.001
Hip	Coxal	*Acetabulum*	0.654	<0.001	0.392	<0.001	0.284	<0.001	-	-	0.649	<0.001	0.438	<0.001	0.331	<0.001	-	-
	Femur	Femur proximal end	0.449	<0.001	0.223	<0.001	0.240	<0.001	-	-	0.455	<0.001	0.200	<0.001	0.257	<0.001	-	-
Knee	Femur	Femur distal end	0.400	<0.001	0.284	<0.001	0.330	<0.001	0.166	<0.001	0.409	<0.001	0.300	<0.001	0.333	<0.001	0.229	<0.001
	Tibia	Tibia proximal end	0.423	<0.001	0.223	<0.001	0.197	<0.001	-	-	0.402	<0.001	0.2	<0.001	0.195	<0.001	0.146	<0.001
	Patella	*Patella*	0.456	<0.001	0.307	<0.001	0.309	<0.001	0.109	0.002	0.488	<0.001	0.288	<0.001	0.288	<0.001	0.178	<0.001
Ankle	Tibia	Distal end	0.268	<0.001	-	-	-	-	-	-	0.279	<0.001	0.055	0.102	0.054	0.107	-	-
	Fibula	Distal end	0.133	<0.001	-	-	-	-	-	-	0.151	<0.001	-	-	-	-	-	-

Correlation at a 0.001 leve of significance (2-tailed)
* Correation at a **0.05 level** of **significance** (2-tailed)

6.1.2 Osteoarthritis (OA)

6.1.2.1 OA: summary statistics

The frequency of individuals with a positive diagnosis of OA varies strongly between the different joints considered. Table 32 shows the frequency of cases according to joint, as well as sex of the individuals.

Table 32- Frequency and percentages of positive cases of OA. Overall number of cases per joint and distribution according to the sex of the individuals.

	Left	Left				Right	Right			
		Male		Female			Male		Female	
Joint	Present (%)*/Absent	n	%**	n	%**	Present (%)*/Absent	n	%**	n	%**
Shoulder[1]	78 (13.1) / 596	32	41	46	59	59 (10) / 592	26	44.1	33	55.9
Shoulder[2]	134 (22.5) / 596	57	43	77	57.5	123 (20.7) / 594	60	48.8	63	51.2
Elbow	85 (14.4) / 592	36	42	49	57.6	76 (12.8) / 593	31	40.8	45	59.2
Wrist	30 (5.1) / 583	19	63	11	36.7	24 (4.2) / 580	13	54.2	11	45.8
Hip	180 (30.1) / 599	89	49	91	50.6	187 (31.1) / 601	92	49.2	95	50.8
Knee	127 (21.1) / 602	40	32	87	68.5	127 (21.1) / 602	43	33.9	84	66.1
Ankle	4 (0.7) / 601	1	25	3	75	10 (1.7) / 598	8	80	2	20

Shoulder[1] - Includes the follwing articular surfaces: glenoid cavity and humerus proximal end (head).
Shoulder[2] - Includes the following articular surfaces: acromion articular surface of the clavicle and sacpula, glenoid cavity and humerus proximal end (head)
*- Percentage according to total number of observations; **- Percentage according to positive cases of OA..

Analysis of side frequency, bilateral asymmetry, revealed that the bilateral occurrence of OA was highly statistical significant according to chi-square and Fisher's exact test ($p<0.001$). The test proved that the risk of having a lesion, or not, on one side bore a close relationship to its presence, or absence, on the opposite side. The positive relationship found is more related with the absence of OA, than its presence. However, when positively diagnosed the majority of individuals presented it bilaterally, with the exception of the ankle: of the fourteen individuals with OA, none had bilateral pathology. Shoulder[2] (includes the following articular surfaces: acromion articular surface of the clavicle and sacpula, glenoid cavity and humerus head), hip and knee left side joints had an overall higher frequency of OA.

6.1.2.2 OA: analysis according to skeletal collection

Statistically significant associations between collections and OA were found in a considerable number of joints (Table 33). Non-significance was only found on the left wrist (p=0.264), left ankle (p=1), right wrist (p=1) and ankle (p=0.752). These joints corresponded to cases were the frequency of OA was the lowest (Table 32). Despite the high level of significance associated with the sexes, according to the Cramer's V test, the strength of the associations found were weak, ranging only from 0.151 (right elbow) to 0.278 (left knee). Overall, the probability of having OA was higher in the Lisbon collection as its individuals had the highest perceptual values of OA, with the exception of the left ankle and right wrist, where both collections had the same value of individuals affected with OA.

Table 33 – Chi-square test results: assessment of the association between OA and skeletal collection.

	Left side							Right side						
	Lisbon		Coimbra					Lisbon		Coimbra				
	n/N	%	n/N	%	$\chi^2_{(df=1)}$	P*	Cramer's V	n/N	%	n/N	%	$\chi^2_{(df=1)}$	P*	Cramer's V
Shoulder[1]	55/301	18.3	23/295	7.8	14.374	<0.001	0.155	46/299	15.4	13/293	4.4	19.767	<0.001	0.183
Shoulder[2]	94/301	31.2	40/295	13.6	26.691	<0.001	0.212	88/301	29.2	35/293	11.9	27.034	<0.001	0.213
Elbow	59/295	20	26/297	8.8	15.221	<0.001	0.16	53/297	17.8	23/296	7.8	13.467	<0.001	0.151
Wrist	18/288	6.3	12/295	4.1	1.422	0.264	non sig.	12/289	4.2	12/291	4.1	0.001	1	non sig.
Hip	127/302	42.1	53/297	17.8	41.746	<0.001	0.264	128/303	42.2	59/298	19.8	35.314	<0.001	0.242
Knee	98/303	32.3	29/299	9.7	46.358	<0.001	0.278	95/303	31.4	32/299	10.7	38.556	<0.001	0.253
Ankle	2/303	0.7	2/298	0.7	Fisher's	1	non sig.	6/300	2	4/298	1.3	Fishers'	0.752	non sig.

*- Exact significance, two-tailed. Whenever 50% of the cells had and expected count less than 5, Fisher's exact test result was presented.

Shoulder[1] - Includes the following articular surfaces: glenoid cavity and humerus proximal end (head).

Shoulder[2] - Includes the following articular surfaces: acromion articular surface of the clavicle and scapula, glenoid cavity and humerus proximal end (head).

6.1.2.2.1 OA: analysis of sex differences per skeletal collection sub-sample

When collection sub-samples were analysed separately, according to sex, slightly different results were found. In the Lisbon collection (LLSC) (Table 34) statistical significance was only achieved for the left wrist and both left and right knees (p<0.05). On the knees women had higher probability of OA, whilst in the left wrist men had higher probability of OA (9.6% versus 2.8% in women). Other cases where men had higher probability of OA, although the results were not statistically significant were: left hip (men 43% versus 41.1% in women), right wrist (men 4.8% versus 3.5% in women) and right hip (men 42.7% versus 41.8% in women). In the remaining cases women exhibited higher perceptual values than men. In the Coimbra collection (CISC) (Table 35), statistical significance between sexes was only achieved for the knees (p<0.05), in both cases the probability of OA was higher in women. In this collection, and contrary to the Lisbon collection, women posses the higher perceptual values, therefore they were probabilistically more prone to OA than men. According to the Cramer's V test all statistical significant relationships found were fairly weak, varying between 0.283 for the left knee and 0.140 for the left wrist of the Lisbon collection. Hence, although an association was found, this was of a weak nature.

Table 34 – Chi-square test results: assessment of the association between OA and sex in the Lisbon collection.

	Lisbon														
Left	Female		Male					Right	Female		Male				
	n/N	%	n/N	%	$\chi^2_{(df=1)}$	P*	Cramer's V		n/N	%	n/N	%	$\chi^2_{(df=1)}$	P*	Cramer's V
Shoulder[1]	31/150	20.7	24/151	15.9	1.148	0.300	non sig.		24/150	16	22/149	14.8	0.088	0.873	non sig.
Shoulder[2]	54/150	36	40/151	26.5	3.169	0.820	non sig.		44/151	29.1	44/150	29.3	0.001	1.000	non sig.
Elbow	34/148	23	25/147	17	1.641	0.244	non sig.		30/148	20.3	23/149	15.4	1.183	0.292	non sig.
Wrist	4/142	2.8	14/146	9.6	5.634	0.026	0.14		5/142	3.5	7/147	4.8	0.279	0.770	non sig.
Hip	62/151	41.1	65/151	43	0.122	0.816	non sig.		64/153	41.8	64/150	42.7	0.22	0.908	non sig.
Knee	66/152	43.4	32/151	21.2	17.105	<0.001	0.238		60/152	39.5	35/151	23.2	9.345	0.003	0.176
Ankle	1/153	0.7	1/153	0.7	Fisher'	1	non sig.		1/150	0.7	5/150	3.3	Fisher's	0.214	non sig.

*- Exact significance, two-tailed. Whenever 50% of the cells had and expected count less than 5, Fisher's exact test result was presented.
Shoulder[1] - Includes the following articular surfaces: glenoid cavity and humerus proximal end (head).
Shoulder[2] - Includes the following articular surfaces: acromion articular surface of the clavicle and sacpula, glenoid cavity and humerus proximal end (head).

Table 35 - Chi-square test results: assessment of the association between OA and sex in the Coimbra collection.

	Coimbra														
Left	Female		Male					Right	Female		Male				
	n/N	%	n/N	%	$\chi^2_{(df=1)}$	P*	Cramer's V		n/N	%	n/N	%	$\chi^2_{(df=1)}$	P*	Cramer's V
Shoulder[1]	15/150	10	8/145	5.5	2.061	0.193	non sig.		9/147	6.1	4/146	2.7	1.977	0.256	non sig.
Shoulder[2]	23/150	15.3	17/145	11.7	0.819	0.399	non sig.		19/147	12.9	16/146	11	0.269	0.719	non sig.
Elbow	15/149	10.1	11/148	7.4	0.645	0.539	non sig.		15/148	10.1	8/148	5.4	2.31	0.192	non sig.
Wrist	7/148	4.7	5/147	3.4	0.333	0.77	non sig.		6/148	4.1	6/143	4.2	0.004	1	non sig.
Hip	29/149	19.5	24/148	16.2	0.534	0.545	non sig.		31/149	20.8	28/149	18.8	0.19	0.771	non sig.
Knee	21/150	14	8/149	5.4	6.358	0.018	0.146		24/150	16	8/149	5.4	8.839	0.004	0.172
Ankle	2/1510	1.3	0/148	0	Fisher's	0.498	non sig.		1/149	0.7	3/149	2	Fishers'	0.622	non sig.

*- Exact significance, two-tailed. Whenever 50% of the cells had and expected count less than 5, Fisher's exact test result was presented.
Shoulder[1] - Includes the following articular surfaces: glenoid cavity and humerus proximal end (head).
Shoulder[2] - Includes the following articular surfaces: acromion articular surface of the clavicle and sacpula, glenoid cavity and humerus proximal end (head).

6.1.2.3 OA: analysis according to sex

For the total sample statistically significant association between sex and OA was only found in the knee joint, both left (p<0.001) and right (p<0.001). Women accounted for a significant higher rate of OA when compared to men (Table 36).

Although in the remaining joints no association was found, the probability of women having OA was higher than men (see Table 32, section 6.1.2.1), with the exception of the wrist joints (left and right) and right ankle. In these cases the percentage of men with OA was higher that the one observed in women.

Table 36 – Chi-square test results: assessment of the association between OA and sex in the baseline sample.

	Left			Right		
	$\chi^2_{(df=1)}$	P*	Cramer's *V*	$\chi^2_{(df=1)}$	P*	Cramer's *V*
Shoulder[1]	2.679	0.115	non sig.	0.871	0.411	non sig.
Shoulder[2]	3.512	0.063	non sig.	0.069	0.84	non sig.
Elbow	2.22	0.16	non sig.	3.012	0.87	non sig.
Wrist	2.163	0.189	non sig.	0.174	0.835	non sig.
Hip	0.023	0.929	non sig.	0.033	0.861	non sig.
Knee	21.65	<0.001	0.19	16.432	<0.001	0.165
Ankle	Fisher's	0.624	non sig.	3.661	0.106	non sig.

*- Exact significance, two-tailed. Whenever 50%of the cells had and expected count less than 5, Fisher's exact test result was presented.
Shoulder[1] - Includes the follwing articular surfaces: glenoid cavity and humerus proximal end (head).
Shoulder[2] - Includes the following articular surfaces: acromion articular surface of the clavicle and sacpula, glenoid cavity and humerus proximal end (head).

The higher probability of women having OA may have its relationship not on the sex, but on the fact that individuals aged 60 to 98 years at time of death represented 37.8% (228/603) of the total sample, of which 60.5% (138/228) were women. This is particularly true in the Lisbon Collection (see Chapter 5, section 5.2.2). The relation between age and OA was explored in the following section.

6.1.2.4 OA: analysis according to age at death

Mann-Whitney statistic revealed a statistically significant difference between the mean age of individuals with and without OA in all joints considered (Table 37). However, care must be taken in the interpretation of the left ankle results, as the frequency of OA cases was very small: only four cases were counted. Individuals with OA were on average considerably older than those without. The highest mean average difference between individuals with, and without OA varied from 14.67 years, for the left wrist, and 25.31 years for the left ankle. The next highest mean difference was found on the left knee: 21.44 years. The mean age of individuals without OA ranged from 46.32 years, for the right hip, and 52.69 for the left ankle. The mean age of individuals with OA was considerably higher: the lowest value found was of 66.70 years for the left wrist, and the highest 78 years for the left ankle (Table 37; detailed description Table14, Appendix_DBC).

6.1.2.5 OA: analysis of age at death differences of individuals with OA according to sex

The Mann-Whitney statistical test revealed a statistically significant difference between the mean age of women and men with OA (Table 38). The only exception was found on the knees (left, $p=0.104$; right, $p=0.055$), although in the case of the right knee the p-value is marginally significant, and therefore one can allow for it being representative of sex differences. No statistics were given for the ankles, as the number of cases was very small (left=4 cases, right=10 cases), nevertheless, the descriptive statistics showed that both men and women age at death mean value of individuals with OA was either identical (left=78), or slightly higher in men (right, men=65.63 *versus* women=65). Overall, the mean age of women with OA was higher than men.

These results indicate that the association previously found between sex and OA may in fact be related to the age of the individuals, and not sex. To determine more specifically the real contribution of sex and age in the outcome of OA a logistic regression procedure was applied. The results are summarized in Table 39.

The addition of the variables sex and age, to the baseline model of the test, proved to be statistically significant for all the models. However, a distinct set of results was found for upper and lower limbs. In the upper limb, with the exception of OA of the left wrist, age revealed to be the only significant predictor in the outcome of OA accordingly to the Wald statistics ($p<0.001$). The value of $exp\,\beta$ for age indicates that as the value of age goes up by one, the odds of having OA also increased.

Furthermore, because the confidence interval does not cross 1 we can conclude, with reasonable confidence, that the relationship between the outcome variable (OA) and predictor (age) found in this sample would be found in 95% of samples from the same population. Sex, on the other hand, revealed to be neither a significant ($p>0.05$) nor a reliable predictor of OA because in its case the confidence interval crosses 1. Nevertheless, it can be concluded that, as sex changes from female to male the odds of positive outcome of OA decreased. In the case of OA of the left wrist, both sex and age were significant and reliable predictors (age, $p<0.001$; sex, $p=0.018$).

In the lower limb, sex and age were both significant (age, $p<0.001$; sex p-value varied from 0.005 on the right hip to 0.040 on the right ankle) and reliable predictors for OA. For all joints, as age increased so did the odds of having OA, and as sex changed from female to male, in the hip joint, the odds of having OA decreased. However, in the knee joints results, as sex changes from female to male the odds of having OA increased.

Further tests to these models, using the Hosmer-Lemeshow Goodness-of-Fit test, revealed that almost all of them fit the data well to, that is: there were no differences between the observed and predicted values by the models, implying that the model's estimates fit the data at an acceptable level ($p>0.05$). The exception concerns the model regarding OA for the left hip. The Hosmer-Lemeshow goodness-of-fit test statistic was significant ($\chi^2_{(8)}=16.701$, $p=0.033$) and therefore we must conclude that the predicted values of the model significantly differ from the observed data; as such, all consideration must be done with caution.

The overall success rate of classification of the models tended to be high. The highest value found was 95.8% for the right wrist, and the lowest 75.3% for the left hip. Models where both age and sex were significant had a lower overall success rate, but could predict a fair percentage of positive cases of OA (between 33% and 56%). However, all models with high overall success rate (above 85%) failed to correctly predict most cases of positive OA. Some of them failing to predict any cases such were the models developed for the wrists: all observations predicted represented cases of absence of OA.

6.1.2.6 OA: summary of results

The frequency of cases of OA varied accordingly with the joints, sex and skeletal samples. The highest percentages of cases were found on the hips, shoulders and knees, on women, and on the LLSC. Age revealed to be of major importance in the presence of OA, whist sex, did not. This affirmation is limited to the upper limb. Results of the lower limb showed that both sex and age were significant factors in the outcome of OA. The number of cases reported as OA was significantly lower than the number of joints affected by DBC individually.

Table 37 - Mann-Whitney test results: assessment of age differences between individuals with and without OA.

Joints	Left side									Right side								
	Absence of OA			Presence of OA						Absence of OA			Presence of OA					
	N	Mean	S.D.	N	Mean	S.D.	U	Z	P*	N	Mean	S.D.	N	Mean	S.D.	U	Z	P*
Shoulder[1]	508	50.26	18.03	78	70.68	13.38	7702.0	-8.818	<0.001	539	50.88	18.37	59	72.20	11.03	5363.5	-8.312	<0.001
Shoulder[2]	462	48.16	17.62	134	69.32	12.98	10948.0	-10.944	<0.001	471	48.56	17.87	123	69.48	12.28	10420.5	-10.944	<0.001
Elbow	507	50.33	18.35	85	69.05	13.16	9231.5	-8.441	<0.001	517	50.38	18.23	76	71.08	11.36	7126.0	-8.979	<0.001
Wrist	553	52.03	18.77	30	66.7	13.93	4589.5	-4.125	<0.001	554	51.92	18.56	24	68.88	13.38	3184.5	-4.325	<0.001
Hip	419	46.71	17.50	180	67.23	13.37	13927.0	-12.249	<0.001	414	46.32	17.37	187	67.4	13.02	13428.5	-12.83	<0.001
Knee	475	48.32	17.70	127	69.76	12.45	10330.0	-11.393	<0.001	475	48.48	17.78	127	69.2	13.09	11210.0	-10.887	<0.001
Ankle	597	52.69	18.82	4	78	8.04	282.5	-2.634	0.005	588	52.49	18.90	10	65.5	9.94	1712.0	-2.267	0.019

*Monte Carlo significance two-tailed.

Shoulder[1] - Includes the follwing articular surfaces: glenoid cavity and humerus proximal end (head).

Shoulder[2] - Includes the following articular surfaces: acromion articular surface of the clavicle and sacpula, glenoid cavity and humerus proximal end (head).

Table 38 - Mann-Whitney test results: assessment of age differences between individuals with OA according to sex sub-samples.

Joints	Left side									Right side								
	Female			Male						Female			Male					
	N	Mean	S.D.	N	Mean	S.D.	U	Z	P*	N	Mean	S.D.	N	Mean	S.D.	U	Z	P*
Shoulder[1]	46	74.93	10.87	32	64.56	14.41	430.0	-3.111	0.002	33	75.58	9.747	26	67.92	11.25	264.5	-2.515	0.013
Shoulder[2]	77	73.78	11.11	57	63.3	12.98	1217.5	-4.399	<0.001	63	74.33	11.27	60	64.38	11.26	996.5	-4.523	<0.001
Elbow	49	72.45	11.96	36	64.42	13.45	594.0	-2.563	0.01	45	73.42	11.44	31	67.68	10.52	508.5	-1.999	0.045
Wrist	11	80.27	9.001	19	58.84	9.483	11.5	-4.004	<0.001	11	76.73	10.25	13	62.23	12.29	26.0	-2.642	0.007
Hip	91	71.89	12.16	89	62.46	12.91	2433.0	-4.627	<0.001	95	71.36	12.55	92	63.3	12.26	2767.0	-4.334	<0.001
Knee	87	71.13	12.18	40	66.78	12.66	1425.0	-1.638	0.104	84	70.99	12.51	43	65.7	13.63	1428.5	-1.924	0.055
Ankle	3	78.0	9.849	1	78	—	—	—	—	2	65.0	4.243	8	65.63	11.15	—	—	—

*Monte Carlo significance two-tailed.

Shoulder[1] - Includes the follwing articular surfaces: glenoid cavity and humerus proximal end (head).

Shoulder[2] - Includes the following articular surfaces: acromion articular surface of the clavicle and sacpula, glenoid cavity and humerus proximal end (head).

Table 39 – Logistic regression results for OA: upper and lower limbs.

Joint	Predictors	B	S.E.	Wald (d.f.=1)	p	Exp(B)	95.0% C.I. for EXP(B) Lower	95.0% C.I. for EXP(B) Upper	Log-likelihood statistic $\chi^2_{(2)}$	Log-likelihood statistic p	H & L goodness-of-fit statistic $\chi^2_{(8)}$	H & L goodness-of-fit statistic p	R^2 Cox & Snell	R^2 Nagelkerke	Sensitivity of prediction %	Specificity of prediction %	Overall success rate %
Left shoulder	**Sex**	-0.09	0.28	0.098	0.754	0.917	0.535	1.573	88.842	<.001	7.131	0.523	0.137	0.254	6.4	99	86.9
	Age	0.072	0.01	59.802	**<0.001**	1.075	1.055	1.094									
	Constant	-6.26	0.63	99.425	**<0.001**	0.002											
Right shoulder	**Sex**	-0.34	0.31	1.155	0.282	0.706	0.389	1.317	79.24	<.001	8.608	0.376	0.125	0.262	1.7	99.6	87.9
	Age	0.081	0.01	52.018	**<0.001**	1.085	1.061	1.109									
	Constant	-7.1	0.77	84.545	**<0.001**	0.001											
Left elbow	**Sex**	-0.09	0.26	0.119	0.730	0.914	0.547	1.525	77.825	<.001	6.862	0.552	0.123	0.22	3.5	99.4	85.6
	Age	0.063	0.01	56.594	**<0.001**	1.065	1.048	1.083									
	Constant	-5.56	0.56	99.526	**<0.001**	0.004											
Right elbow	**Sex**	-0.09	0.28	0.102	0.749	0.915	0.529	1.581	89.374	<.001	10.951	0.204	0.14	0.261	7.9	98.8	87.2
	Age	0.075	0.01	59.676	**<0.001**	1.078	1.057	1.098									
	Constant	-6.47	0.65	97.729	**<0.001**	0.002											
Left wrist	**Sex**	-0.98	0.41	5.608	**0.018**	0.377	0.168	0.845	23.835	<.001	12.409	0.134	0.04	0.12	0	100	94.9
	Age	0.052	0.01	18.016	**<0.001**	1.054	1.029	1.08									
	Constant	-5.63	0.81	48.49	**<0.001**	0.004											
Right wrist	**Sex**	-0.64	0.45	2.03	0.154	0.53	0.221	1.269	22.137	<.001	3.801	0.875	0.038	0.129	0	100	95.8
	Age	0.061	0.02	17.271	**<0.001**	1.062	1.033	1.093									
	Constant	-6.53	0.98	44.478	**<0.001**	0.001											
Left hip	**Sex**	-0.56	0.22	6.644	**0.010**	0.569	0.371	0.874	173.012	<.001	16.701	0.033	0.251	0.356	50.6	85.9	75.3
	Age	0.078	0.01	116.09	**<0.001**	1.081	1.066	1.096									
	Constant	-5.03	0.43	134.59	**<0.001**	0.007											
Right hip	**Sex**	-0.62	0.22	7.861	**0.005**	0.539	0.35	0.83	189.47	<.001	11.31	0.185	0.27	0.381	56.1	86.2	76.9
	Age	0.082	0.01	122.91	**<0.001**	1.085	1.07	1.101									
	Constant	-5.2	0.44	138.73	**<0.001**	0.006											
Left knee	**Sex**	0.637	0.24	7.113	**0.008**	1.891	1.184	3.019	152.684	<.001	7.006	0.536	0.224	0.348	33.1	92.2	79.7
	Age	0.075	0.01	89.225	**<0.001**	1.078	1.061	1.094									
	Constant	-6.14	0.53	133.28	**<0.001**	0.002											
Right knee	**Sex**	0.482	0.23	4.227	**0.040**	1.619	1.023	2.563	138.386	<.001	6.188	0.626	0.205	0.319	33.9	92.6	80.2
	Age	0.071	0.01	85.822	**<0.001**	1.073	1.057	1.09									
	Constant	-5.79	0.51	130.39	**<0.001**	0.003											

6.2 Musculoskeletal Stress Markers (MSM)

6.2.1 MSM summary statistics: frequency and percentages per enthesis sites

Tables 40 and 41 summarized the frequency, percentage and descriptive statistics of MSM per enthesis anatomical site[57]. The frequencies of individuals affected varied considerably between sites: the lowest percentage of cases was found at the medial supracondylar line of the left femur (9.2%), and the highest value was found on the soleal line of the right tibia (68.6%). Overall, higher numbers of cases were recorded on the lower limb, particularly on the femurs and os coxae. MSM mean score values were higher in the lower limb, when compared to the upper limb, suggesting more severe lesions. This was particularly true for the os coxae, femurs, calcanei and *patellae*. The upper limb MSM mean score was no greater than 0.88, found on the lesser trochanter of the right humerus (Tables 40-41; Figure 38).

Statistically significant bilateral differences were found in several entheses according to the Wilcoxon signed-rank test. Although some individuals showed a significant increase in the severity of lesions from right to left, mostly observed on the lower limb, the majority of individuals exhibited an increase in the severity of lesions from left to right side. This was particularly true for the upper limb and specifically in the humerus. In general, when statistical significance was achieved more severe degrees of lesion expression were found on the right side. There were some cases of marginal statistical values (humerus greater tubercule, p=0.049; femur medial spracondylar line, p=0.051; and tibia fibular notch, p=0.049). They also pointed to right side dominance (Tables 40 and 41).

[57] As discussed in the methodology chapter (4), rather than considering lesions per entheses, the emphasis was given to the anatomical site where several tendons may act upon. Hence, whenever refering to a specific enthesis emphasis should be place in the anatomical site. There are a few exceptions in which the site observed was the locus of a single enthesis attachment; however, in the majority of cases the entheses/sites should be understood as a complex "organ" of neighbouring entheses.

Table 40 – Summary statistics of the MSM for the upper limb (baseline sample). Wilcoxon signed rank test results for bilateral differences also presented.

			Left side					Right side					Wilcoxon signed rank test		Side dominance
Bone	No.	Enthesis	n^a	n^b/N^c	%	X^d	S.D.^{e}	n^a	n^b/N^c	%	X^d	S.D.^{e}	Z-scores	P*	
Clavicle	1	Acromial extremity – *Trapezius muscle*	206	78/558	37	0.5	0.748	192	62/552	35	0.5	0.688	**-2.221**	**0.027**	Left > Right
	2	Acromial extremity – *Deltoideus muscle*	295	132/562	53	0.8	0.864	296	116/559	53	0.8	0.816	-0.749	0.455	Not significant
	3	Impression for costoclavicular ligament	224	86/567	40	0.6	0.779	166	84/573	29	0.5	0.908	-1.057	0.304	Not significant
Scapula	4	Corocoid process	115	56/530	28	0.4	0.727	142	63/525	27	0.4	0.742	-0.191	0.860	Not significant
	5	Acromion - *Deltoideus muscle*	123	43/490	25	0.3	0.64	150	61/491	31	0.4	0.733	**-3.064**	**0.002**	Right > Left
	6	Acromion – *Trapezius muscle*	112	32/492	23	0.3	0.589	127	36/492	26	0.3	0.629	-1.413	0.176	Not significant
Humerus	7	Surgical neck	198	121/554	36	0.6	0.942	220	148/559	39	0.7	1.017	-0.421	0.658	Not significant
	8	Greater tubercle	113	67/508	22	0.4	0.792	124	73/508	24	0.4	0.836	**-1.932**	**0.049**	Right > Left
	9	Lesser tubercle	363	129/577	63	0.9	0.78	362	136/579	63	0.9	0.801	**-3.957**	**<0.001**	Right > Left
	10	Deltoid tuberosity	57	30/515	11	0.2	0.59	94	39/500	19	0.3	0.657	**-4.137**	**<0.001**	Right > Left
	11	Lateral epicondyle	138	70/501	28	0.4	0.8	192	102/491	39	0.7	0.933	**-5.693**	**<0.001**	Right > Left
	12	Medial epicondyle	248	72/557	45	0.6	0.715	272	97/562	48	0.7	0.765	**-2.971**	**0.002**	Right > Left
Radius	13	Radial tuberosity	315	152/570	55	0.9	0.947	311	138/566	55	0.9	0.958	-0.275	0.783	Not significant
	14	Inter-osseous border - *Pronator teres* insertion	251	52/546	46	0.6	0.662	222	44/533	42	0.50	0.651	**-2.074**	**0.039**	Left > Right
Ulna	15	Olecranon	67	24/526	13	0.2	0.568	99	51/516	19	0.3	0.753	**-3.88**	**<0.001**	Right > Left
	16	Ulna tuberosity	133	32/580	23	0.3	0.581	176	62/577	31	0.4	0.708	**-4.868**	**<0.001**	Right > Left

a)- overall number of individuals with MSM; b) - number of individuals with severe to moderate lesions of MSM; c) - total number of individuals examined; perceptual values refers to all individuals with MSM lesions; d) – mean value of MSM degrees; e) – standard deviation; P * - two-tailed Monte Carlo significance test. Bold p-values refer to enthesis where statistical significance was found.

Table 41 - Summary statistics of the MSM for the Lower limb (baseline sample). Wilcoxon signed rank test results for bilateral differences also presented.

			Left side					Right side					Wilcoxon signed-rank test		Side dominance
Bone	No.	Enthesis	n^a	n^b/N^c	%	X^d	S.D.^{e}	n^a	n^b/N^c	%	X^d	S.D.^{e}	Z-scores	P*	
Os coxa	17	*Ischium* tuberosity	343	232/580	59	1.2	1.131	336	235/583	58	1.1	1.133	-0.982	0.349	Not significant
	18	Iliac crest	351	241/551	64	1.3	1.146	332	227/544	61	1.2	1.104	**-3.194**	**0.001**	Left > Right
Femur	19	Greater trochanter	285	213/583	49	1	1.149	290	193/568	51	1	1.115	-0.312	0.756	Not significant
	20	Gluteal tuberosity	377	207/586	64	1	0.915	384	199/592	65	1	0.905	-0.952	0.365	Not significant
	21	Linea aspera	328	169/595	55	0.9	0.892	301	139/599	50	0.8	0.862	**-4.709**	**<0.001**	Left > Right
	22	Medial supracondylar line	55	27/595	9.2	0.2	0.509	77	36/599	13	0.2	0.545	**-1.992**	**0.051**	Right > Left
Tibia	23	Anterior tuberosity	259	135/577	45	0.7	0.937	252	135/585	43	0.7	0.938	-0.815	0.423	Not significant
	24	Soleal line	403	157/596	68	1	0.833	407	167/593	69	1	0.847	-1.134	0.257	Not significant
	25	Fibular notch	164	48/577	28	0.4	0.638	186	52/580	32	0.4	0.655	**-1.998**	**0.049**	Right > Left
Calcaneus	26	Posterior surface of calcaneus	270	210/506	50	1.3	1.107	258	222/519	49	1.3	1.086	-0.147	0.891	Not significant
	27	Plantar surface	333	134/522	66	0.8	1.013	347	124/536	67	0.7	1	**-2.08**	**0.034**	Left > Right
Patella	28	Base of anterior surface	233	210/543	45	1.1	1.22	228	190/529	43	1	1.193	-1.492	0.132	Not significant

a)- overall number of individuals with MSM; b) - number of individuals with severe to moderate lesions of MSM; c) - total number of individuals examined; perceptual values refers to all individuals with MSM lesions; d) – mean value of MSM degrees; e) – standard deviation; P * - two-tailed Monte Carlo significance test. Bold p-values refer to enthesis where statistical significance was found.

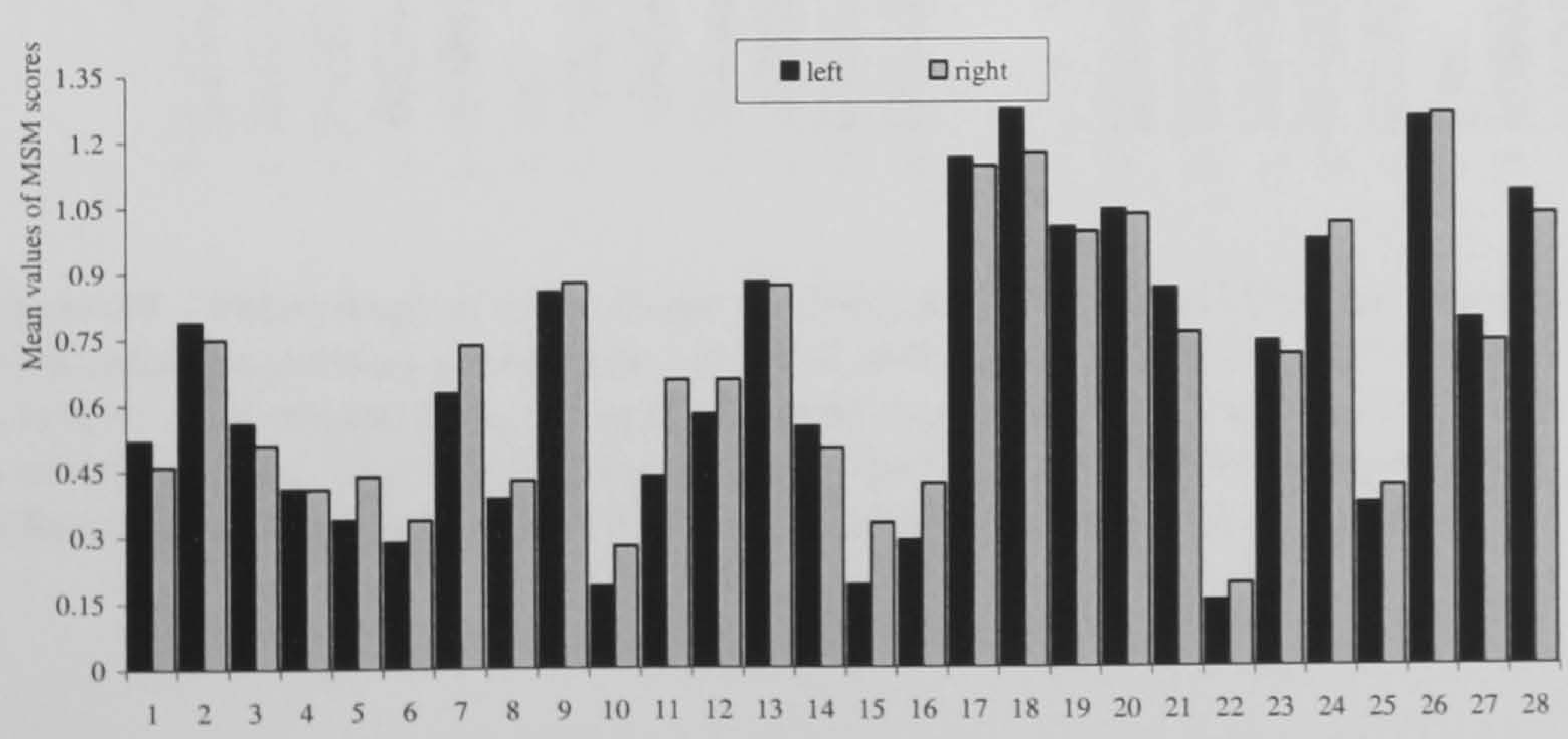

Figure 38 – Mean values of MSM scores per enthesis analysed according to side. Numbers correspond to different entheses analysed (see Tables 40 and 41 for entheses description).

6.2.2 DMSM: summary statistics and bilateral asymmetry

DMSM focuses on the analysis of presence and absence of the of the MSM grade 2 and 3. In DMSM the number of individuals with lesions in DMSM variables was considerably lower, when compared to the ordinal variable (which included lesions grade 1) as illustrated in Figure 39 (and Tables 40 and 41). That is, when the lesser degree of MSM was acknowledged some sites had a notably higher frequency of cases. In some entheses sites the number of cases doubled their count: as it can be observed in site 9 – lesser tubercle of the humerus; and site 4 tibia soleal line. The affirmation is valid for both left and right sides.

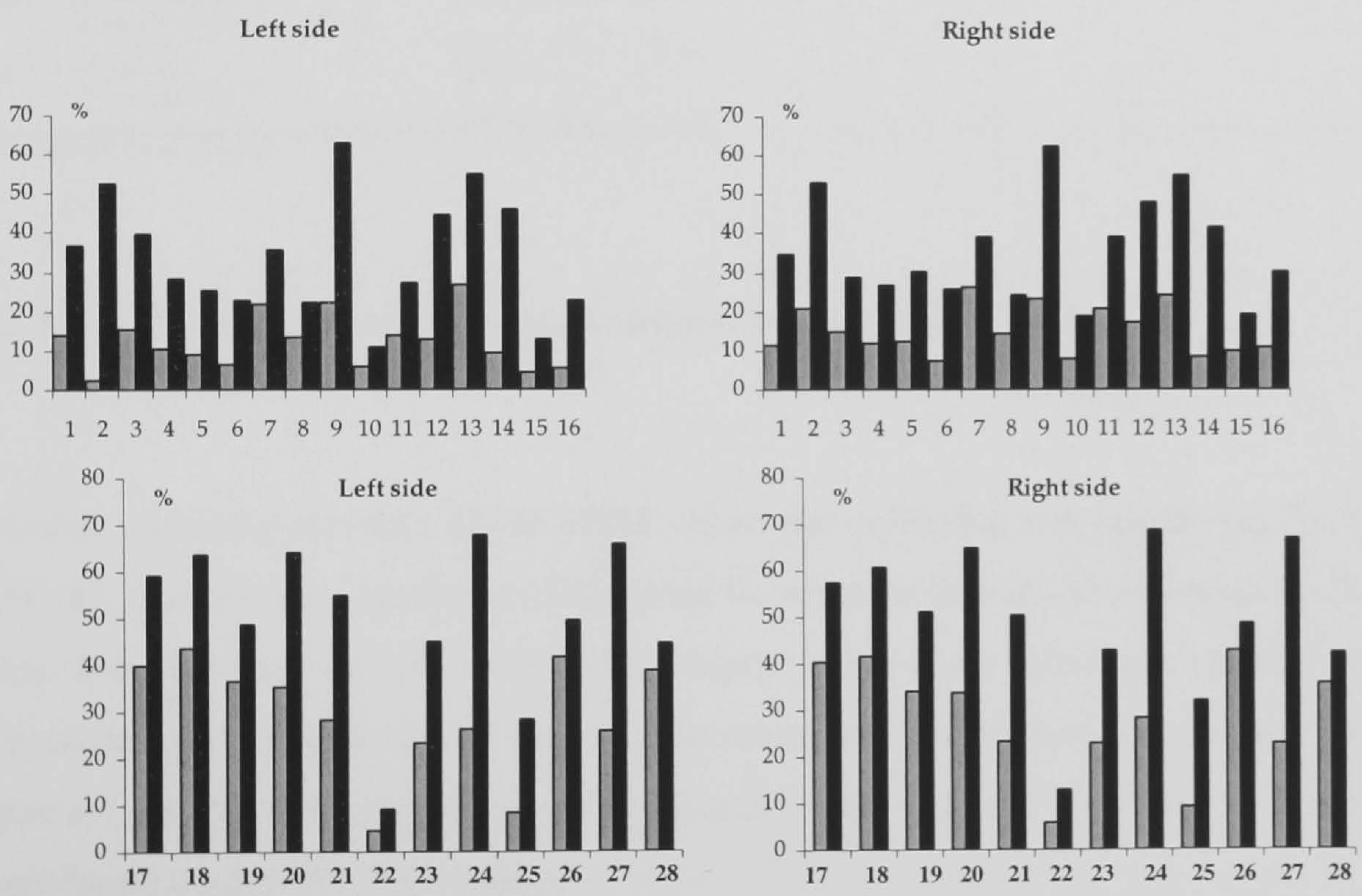

Figure 39 - Percentage of individuals exhibiting MSM and DMSM on the upper and lower limb. The black columns portray percentage values of individuals exhibiting MSM lesions that ranged from slight to severe. As a comparison, the gray columns represent the perceptual values individuals with moderate to severe lesions. Top charts refer to upper limbs, lower charts to lower limbs. Numbers correspond to different entheses analysed (see Tables 40 and 41 for entheses description).

Statistically significant bilateral association was found for almost all sites observed (Table 42), with the exception of the impression of the costoclavicular ligament on the clavicles ($\chi^2_{(1)}$=0.004, p=1), and the greater trochanter on the femurs ($\chi^2_{(1)}$=1.100, p=0.302). The results are indicative that, the presence of moderate to severe lesions was constantly bilateral: that is, the risk of an individual having both right and left sites affected was significant. The Cramer's V values represented moderate to very strong associations, reinforcing the significant results found.

Table 42 – Chi-square results: association between DMSM and laterality.

Bone	No.	Enthesis	$\chi^2_{(df=1)}$	P*	Cramer's V	Bone	No.	Enthesis	$\chi^2_{(df=1)}$	P*	Cramer's V
Clavicle	1	Acromial extremity – *Trapezius muscle*	180.584	<0.001	0.588	Os coxa	17	*Ischium* tuberosity	357.035	<0.001	0.789
	2	Acromial extremity – *Deltoideus muscle*	159.445	<0.001	0.547		18	Iliac crest	347.055	<0.001	0.811
	3	Impression for costoclavicular ligament	0.004	1	0.003	Femur	19	Greater trochanter	[illegible]	0.302	0.045
Scapula	4	Corocoid process	104.467	<0.001	0.458		20	Gluteal tuberosity	287.933	<0.001	0.705
	5	Acromion - *Deltoideus muscle*	Fisher's	<0.001	0.595		21	Linea aspera	310.367	<0.001	0.724
	6	Acromion – *Trapezius muscle*	Fisher's	<0.001	0.62		22	Medial supracondylar line	Fisher's	<0.001	0.503
Humerus	7	Surgical neck	272.84	<0.001	0.717	Tibia	23	Anterior tuberosity	235.279	<0.001	0.643
	8	Greater tubercle	156.803	<0.001	0.575		24	Soleal line	240.425	<0.001	0.639
	9	Lesser tubercle	246.03	<0.001	0.66		25	Fibular notch	Fisher's	<0.001	0.561
	10	Deltoid tuberosity	219.068	<0.001	0.639	Calcaneus	26	Posterior surface of calcaneus	252.184	<0.001	0.726
	11	Lateral epicondyle	128.757	<0.001	0.538		27	Plantar surface	203.464	<0.001	0.637
	12	Medial epicondyle	121.026	<0.001	0.509	*Patella*	28	Base of anterior surface	308.351	<0.001	0.78
Radius	13	Radial tuberosity	178.522	<0.001	0.573						
	14	Interosseous border - Pronator teres insertion	Fisher's	<0.001	0.493						
Ulna	15	Olecranon	Fisher's	<0.001	0.483						
	16	Ulna tuberosity	Fisher's	<0.001	0.522						

P*- two-tailed Monte Carlo significance test.

6.2.3 MSM: analysis according to skeletal collection

Detailed summary statistics of the MSM values per collection sub-sample can be found in table 43. Statistically significant differences between collections were found in almost all sites. The LLSC sub-sample exhibited the higher mean score values per enthesis site, with the exception of the values of the left olecranon and impression for the costoclavicular ligament on the right clavicle (both non-significant). In these cases higher mean scores were found on the CISC (Coimbra).

When DMSM variables were analysed a higher number of statistical associations were found (Table 44), when compared to MSM variables (Table 43). Individuals of the LLSC had a higher probability of having more severe lesions, with the exceptions of the left olecranon (statistically non-significant) and impression for the costoclavicular ligament on the right clavicle (also non-significant). In this last case, individuals from the CISC presented more severe lesions. The strength of the associations found varied between very weak values (0.08 on the right *ischium* tuberosity) and moderate as the value found on the right soleal line (0.450).

Table 43 – MSM descriptive statistics (collections sub-samples) and Mann-Whitney statistical test results.

			Left side									Right side								
			Lisbon			Coimbra			Mann-Whitney test results			Lisbon			Coimbra			Mann-Whitney test results		
Bone	No.	Enthesis	N	X[a]	s.d[b]	N	X[a]	s.d[b]	U	Z-scores	P*	N	X[a]	s.d[b]	N	X[a]	s.d[b]	U	Z-scores	P*
Clavicle	1	Acromial extremity – *Trapezius muscle*	270	0.874	0.849	288	0.181	0.42	21140.0	-10.875	<0.001	264	0.758	0.776	288	0.188	0.449	22555.0	-9.815	<0.001
	2	Acromial extremity – *Deltoideus muscle*	274	1.142	0.94	288	0.448	0.617	23287.0	-9.065	<0.001	269	1.048	0.899	290	0.479	0.618	25391.5	-7.714	<0.001
	3	Impression for costoclavicular ligament	278	0.835	0.884	289	0.298	0.548	26763.5	-7.878	<0.001	285	0.46	0.862	288	0.552	0.950	39277.5	-1.114	0.266
Scapula	4	Corocoid process	266	0.594	0.878	264	0.22	0.467	28056.0	-5.062	<0.001	255	0.557	0.844	270	0.267	0.600	28527.0	-4.357	<0.001
	5	Acromion - *Deltoideus muscle*	223	0.534	0.758	267	0.18	0.464	22615.5	-6.046	<0.001	225	0.653	0.853	266	0.259	0.553	22773.0	-5.630	<0.001
	6	Acromion – *Trapezius muscle*	225	0.431	0.685	267	0.18	0.464	24555.0	-4.772	<0.001	226	0.434	0.704	266	0.256	0.545	26469.0	-2.986	0.003
Humerus	7	Surgical neck	288	0.848	1.068	289	0.423	0.75	24832.5	-8.973	<0.001	288	0.985	1.133	291	0.493	0.821	25501.0	-8.701	<0.001
	8	Greater tubercle	229	0.511	0.949	279	0.283	0.619	29615.5	-1.948	0.051	230	0.609	1.004	278	0.281	0.630	27670.0	-3.471	<0.001
	9	Lesser tubercle	270	1.163	0.821	284	0.564	0.604	31004.5	-4.567	<0.001	275	1.17	0.824	284	0.584	0.661	30482.5	-5.122	<0.001
	10	Deltoid tuberosity	269	0.273	0.716	288	0.12	0.452	26861.0	-7.014	<0.001	276	0.392	0.781	286	0.198	0.524	25322.0	-8.080	<0.001
	11	Lateral epicondyle	221	0.715	0.993	280	0.229	0.513	23823.0	-5.637	<0.001	210	1	1.111	281	0.399	0.669	21376.5	-5.977	<0.001
	12	Medial epicondyle	231	0.796	0.762	284	0.372	0.6	30518.5	-2.497	0.011	222	0.931	0.817	278	0.399	0.606	27956.5	-2.656	0.007
Radius	13	Radial tuberosity	277	1.123	0.981	293	0.659	0.856	29674.0	-5.921	<0.001	275	1.12	0.984	291	0.639	0.873	28618.0	-6.264	<0.001
	14	Interosseous border - Pronator teres insertion	261	0.77	0.75	285	0.358	0.495	26376.0	-6.596	<0.001	253	0.743	0.741	280	0.282	0.459	23521.5	-7.669	<0.001
Ulna	15	Olecranon	234	0.162	0.523	292	0.216	0.602	32921.0	-1.240	0.220	230	0.396	0.817	286	0.273	0.693	30948.0	-1.681	0.093
	16	Ulna tuberosity	283	0.389	0.687	297	0.195	0.438	37122.0	-3.318	0.001	284	0.641	0.852	293	0.212	0.441	31097.0	-6.482	<0.001
Coxal	17	*Ischium* tuberosity	284	1.236	1.164	296	1.078	1.094	38962.0	-1.598	0.111	289	1.197	1.160	294	1.078	1.104	40312.0	-1.125	0.261
	18	Iliac crest	282	1.667	1.158	269	0.851	0.974	23183.0	-8.219	<0.001	275	1.615	1.109	269	0.725	0.901	20776.0	-9.268	<0.001
Femur	19	Greater trochanter	290	1.41	1.203	293	0.597	0.934	27091.5	-8.206	<0.001	284	1.106	1.151	284	0.87	1.067	36091.0	-2.327	0.020
	20	Gluteal tuberosity	293	1.362	0.902	293	0.717	0.810	26303.0	-8.549	<0.001	297	1.34	0.894	295	0.715	0.804	27119.5	-8.449	<0.001
	21	Linea aspera	298	1.205	0.896	297	0.519	0.745	25709.5	-9.463	<0.001	301	1.093	0.89	298	0.419	0.683	25945.5	-9.693	<0.001
	22	Medial supracondylar line	297	0.185	0.589	298	0.114	0.411	43470.0	-0.737	0.479	301	0.226	0.607	298	0.161	0.472	43935.0	-0.743	0.461
Tibia	23	Anterior tuberosity	283	0.940	1.024	294	0.541	0.799	33052.0	-4.726	<0.001	288	0.934	1.022	297	0.502	0.793	33102.5	-5.282	<0.001
	24	Soleal line	299	1.291	0.851	297	0.657	0.680	26109.0	-9.257	<0.001	298	1.369	0.856	295	0.644	0.664	23380.0	-10.462	<0.001
	25	Fibular notch	292	0.401	0.694	285	0.337	0.574	41012.5	-0.378	0.707	291	0.464	0.725	289	0.36	0.573	40332.5	-1.037	0.299
Calcaneus	26	Posterior surface of calcaneus	232	1.457	1.184	274	1.073	1.006	26053.0	-3.633	<0.001	248	1.411	1.149	271	1.118	1.008	28841.0	-2.899	0.004
	27	Plantar surface	244	0.996	1.188	278	0.608	0.789	29380.0	-2.917	0.003	257	0.934	1.172	279	0.566	0.769	31503.5	-2.715	0.007
Patella	28	Base of anterior surface	255	1.506	1.261	288	0.712	1.051	24304.0	-7.350	<0.001	241	1.419	1.263	288	0.705	1.026	24089.5	-6.569	<0.001

N) - number of cases used in the analysis; a) – mean score of ordinal variable; b) – standard deviation; p*) - two-tailed Monte Carlo significance test.

Table 44 – DMSM frequency results (collections sub-samples) and Chi-square statistical test results.

			Left side							Right side						
			Lisbon		Coimbra					Lisbon		Coimbra				
Bone	No.	Enthesis	n/N	%	n/N	%	$\chi^2_{(df=1)}$	P*	Cramer's *V*	n/N	%	n/N	%	$\chi^2_{(df=1)}$	P*	Cramer's *V*
Clavicle	1	Acromial extremity – *Trapezius muscle*	74/270	27.4	4/288	1.4	78.455	<0.001	0.375	55/264	20.8	7/288	2.4	46.786	<0.001	0.291
	2	Acromial extremity – *Deltoideus muscle*	115/274	42	17/288	5.9	101.64	<0.001	0.425	97/269	36.1	19/290	6.6	73.888	<0.001	0.364
	3	Impression for costoclavicular ligament	73/278	26.3	13/289	4.5	52.147	<0.001	0.303	38/285	13.3	46/288	16	0.797	0.409	Not significant
Scapula	4	Corocoid process	50/266	18.8	6/264	2.3	38.286	<0.001	0.269	45/255	17.6	18/270	6.7	14.973	<0.001	0.169
	5	Acromion - *Deltoideus muscle*	34/223	15.2	9/267	3.4	21.407	<0.001	0.209	48/225	21.3	13/266	4.9	30.302	<0.001	0.248
	6	Acromion – *Trapezius muscle*	23/225	10.2	9/267	3.4	9.426	0.003	0.138	24/226	10.6	12/266	4.5	6.722	0.014	0.117
Humerus	7	Surgical neck	114/288	39.6	15/289	5.2	98.297	<0.001	0.413	112/288	38.9	24/291	8.2	75.621	<0.001	0.361
	8	Greater tubercle	46/229	20.1	21/279	7.5	17.33	<0.001	0.185	52/230	22.6	21/278	7.6	23.183	<0.001	0.214
	9	Lesser tubercle	90/270	33.3	31/284	10.9	40.748	<0.001	0.271	106/275	38.5	42/284	15	40.507	<0.001	0.269
	10	Deltoid tuberosity	56/269	20.8	16/288	5.6	28.785	<0.001	0.227	79/276	28.6	18/286	6.3	49.039	<0.001	0.295
	11	Lateral epicondyle	62/221	28.1	8/280	2.9	65.24	<0.001	0.361	81/210	38.6	21/281	7.5	70.62	<0.001	0.379
	12	Medial epicondyle	22/231	9.5	8/284	2.8	10.445	0.001	0.142	29/222	13.1	10/278	3.6	15.379	<0.001	0.175
Radius	13	Radial tuberosity	102/277	36.8	50/293	17.1	28.425	<0.001	0.223	95/275	34.5	43/291	15	29.97	<0.001	0.23
	14	Inter-osseous border - *Pronator teres* insertion	50/261	19.2	2/285	0.7	53.851	<0.001	0.314	43/253	17	1/280	0.4	48.584	<0.001	0.302
Ulna	15	Olecranon	10/234	4.3	14/292	4.8	0.081	0.836	Not significant	31/230	13.5	20/286	7	6.02	0.017	0.108
	16	Ulna tuberosity	27/283	9.5	5/297	1.7	17.162	<0.001	0.172	58/284	20.4	4/293	1.4	54.612	<0.001	0.308
Coxal	17	*Ischium* tuberosity	121/284	42.6	6	37.5	1.574	0.235	Not significant	128/289	44.3	107/294	36	3.777	0.053	0.08
	18	Iliac crest	169/282	59.9	72/269	26.8	61.53	<0.001	0.334	165/275	60	62/269	23	76.36	<0.001	0.375
Femur	19	Greater trochanter	161/290	55.5	52/293	17.7	89.669	<0.001	0.392	116/284	40.8	77/284	27	11.937	0.001	0.145
	20	Gluteal tuberosity	151/293	51.5	56/293	19.1	67.412	<0.001	0.339	146/297	49.2	53/295	18	64.528	<0.001	0.33
	21	Linea aspera	134/298	45	35/297	11.8	80.537	<0.001	0.368	114/301	37.9	25/298	8.4	73.051	<0.001	0.349
	22	Medial supracondylar line	21/297	7.1	6/298	2	8.782	0.003	0.121	25/301	8.3	11/298	3.7	5.644	0.024	0.097
Tibia	23	Anterior tuberosity	94/283	33.2	41/294	13.9	29.876	<0.001	0.228	97/288	33.7	38/297	13	35.931	<0.001	0.248
	24	Soleal line	128/299	42.8	29/297	9.8	83.854	<0.001	0.375	144/298	48.3	23/295	7.8	120.344	<0.001	0.45
	25	Fibular notch	35/292	12	13/285	4.6	10.425	0.001	0.134	40/291	13.7	12/289	4.2	16.351	<0.001	0.168
Calcaneus	26	Posterior surface of calcaneus	117/232	50.4	93/274	33.9	14.07	<0.001	0.167	127/248	51.2	95/271	35	13.806	<0.001	0.163
	27	Plantar surface	91/244	37.3	43/278	15.5	32.447	<0.001	0.249	86/257	33.5	38/279	14	29.621	<0.001	0.235
Patella	28	Base of anterior surface	143/255	56.1	67/288	23.3	61.405	<0.001	0.336	125/244	51.2	65/288	23	47.257	<0.001	0.298

n) - number of individuals with moderate to severe lesions; N) - total number of individuals observed; p*) - two-tailed Monte Carlo significance test.

6.2.4 MSM: analysis by sex of the individuals

Statistically significant differences were found between the sexes for several sites of entheses, either if the ordinal variables were analyses (Table 45) or DMSM variables (Tables 46). Statistical significant differences were more numerous in the ordinal variables, than the ones found for DMSM. In both ordinal, as well as DMSM variables, no clear pattern of a sex specific dominance was found with the exception of side, that is, if a statistically significant sex-specific value was found on the left side, similar observation was recorded on the right side. On average, women had a higher mean score than men, as well as a higher probability of exhibiting more severe types of lesions.

Bilateral sex differences between MSM scores are given in Table 47. Clear right side dominance was found for both men and women, especially in the upper limb. In the lower limb statistical significance was only found in the male linea aspera ($p=0.005$) and on the calcaneous' plantar surface ($p=0.002$); and on the female iliac crest ($p=0.003$) and linea aspera (<0.001). The females also possess a marginal significance ($p=0.051$) on the medial supracondylar line of the femur. In the lower limb, side dominance was found to be left, contrasting with the overall dextral pattern found in the upper limb.

Table 45 – MSM descriptive statistics (sex sub-samples) and Mann-Whitney statistical test results.

			Left side									Right side								
			Male			Female			Mann-Whitney test result			Male			Female			Mann-Whitney test result		
Bone	No.	Enthesis	N	X[a]	s.d[b]	N	X[a]	s.d[b]	U	Z-scores	P*	N	X[a]	s.d[b]	N	X[a]	s.d[b]	U	Z-scores	P*
Clavicle	1	Acromial extremity – *Trapezius muscle*	277	0.53	0.770	281	0.50	0.728	38394.5	-0.321	0.746	275	0.44	0.690	277	0.48	0.689	36468.5	-1.027	0.304
	2	Acromial extremity – *Deltoideus muscle*	278	0.71	0.860	284	0.86	0.866	35573.0	-2.188	0.029	280	0.69	0.790	279	0.82	0.838	35687.0	-1.910	0.056
	3	Impression for costoclavicular ligament	282	0.60	0.800	285	0.52	0.753	38339.5	-1.084	0.278	291	0.67	1.040	282	0.33	0.702	34995.0	-3.814	0.000
Scapula	4	Corocoid process	257	0.37	0.724	273	0.44	0.731	33003.5	-1.491	0.137	253	0.35	0.728	272	0.46	0.753	31271.0	-2.318	0.020
	5	Acromion - *Deltoideus* muscle	241	0.34	0.627	249	0.34	0.653	29525.5	-0.403	0.687	245	0.42	0.707	246	0.46	0.759	29803.0	-0.260	0.799
	6	Acromion – *Trapezius* muscle	240	0.30	0.571	252	0.29	0.606	29793.0	-0.388	0.704	246	0.35	0.625	246	0.33	0.634	29697.0	-0.465	0.645
Humerus	7	Surgical neck	282	0.92	0.805	295	0.81	0.751	38634.5	-1.583	0.113	287	0.94	0.815	292	0.81	0.784	38403.5	-1.856	0.063
	8	Greater tubercle	254	0.29	0.690	254	0.48	0.874	29004.0	-2.707	0.007	254	0.34	0.763	254	0.52	0.897	29170.5	-2.481	0.013
	9	Lesser tubercle	276	0.62	0.944	278	0.64	0.942	37773.0	-0.368	0.714	280	0.72	1.031	279	0.75	1.003	37985.5	-0.642	0.521
	10	Deltoid tuberosity	282	0.67	0.767	289	0.49	0.651	34107.5	-2.728	0.006	275	0.72	0.790	287	0.60	0.736	36228.0	-1.848	0.065
	11	Lateral epicondyle	254	0.31	0.679	249	0.58	0.886	26542.5	-3.800	0.000	248	0.48	0.853	243	0.84	0.976	23534.0	-4.801	0.000
	12	Medial epicondyle	276	0.11	0.409	257	0.27	0.719	30829.5	-2.527	0.011	249	0.20	0.529	251	0.37	0.755	28186.0	-2.787	0.005
Radius	13	Radial tuberosity	284	0.96	0.980	286	0.80	0.908	37092.0	-1.910	0.056	285	0.92	0.954	281	0.82	0.962	37360.0	-1.474	0.141
	14	Interosseous border - Pronator teres insertion	263	0.60	0.696	283	0.51	0.627	35083.0	-1.299	0.188	255	0.60	0.707	278	0.41	0.580	30473.5	-3.203	0.001
Ulna	15	Olecranon	266	0.25	0.666	260	0.13	0.441	32842.0	-1.723	0.086	262	0.37	0.814	254	0.29	0.683	32567.0	-0.608	0.543
	16	Ulna tuberosity	289	0.29	0.587	291	0.29	0.576	41713.0	-0.228	0.827	281	0.39	0.684	230	0.45	0.730	39783.5	-1.113	0.265
Coxal	17	*Ischium* tuberosity	286	1.00	1.103	294	1.31	1.137	35613.0	-3.345	0.001	289	0.99	1.096	294	1.29	1.151	36291.5	-3.209	0.001
	18	Iliac crest	264	1.19	1.136	287	1.34	1.153	35194.5	-1.500	0.134	260	1.14	1.076	284	1.20	1.131	35917.0	-0.574	0.567
Femur	19	Greater trochanter	289	0.80	1.074	294	1.20	1.187	34491.5	-4.260	<0.001	284	0.95	1.122	284	1.03	1.109	38457.0	-1.028	0.305
	20	Gluteal tuberosity	292	0.97	0.923	294	1.11	0.905	39372.0	-1.827	0.068	295	0.96	0.893	297	1.10	0.913	40018.0	-1.919	0.055
	21	Linea aspera	295	0.90	0.922	300	0.82	0.861	42501.0	-0.893	0.373	299	0.82	0.908	300	0.69	0.809	41881.0	-1.522	0.128
	22	Medial supracondilar line	297	0.13	0.488	298	0.16	0.528	43377.5	-0.825	0.428	299	0.15	0.506	300	0.24	0.579	42037.0	-2.286	0.023
Tibia	23	Anterior tuberosity	290	0.99	1.019	287	0.48	0.770	30287.5	-6.260	<0.001	291	0.95	1.026	294	0.49	0.778	32454.5	-5.640	<0.001
	24	Soleal line	296	1.00	0.815	300	0.95	0.850	42957.0	-0.730	0.465	297	1.04	0.877	296	0.98	0.817	42542.5	-0.719	0.473
	25	Fibular notch	288	0.32	0.620	289	0.42	0.652	37803.0	-2.410	0.016	292	0.35	0.622	288	0.47	0.683	38244.5	-2.297	0.022
Calcaneus	26	Posterior surface of calcaneus	256	1.05	1.047	250	1.46	1.130	25505.0	-4.103	<0.001	262	1.13	1.053	257	1.39	1.106	29259.0	-2.681	0.007
	27	Plantar surface	265	0.75	1.011	257	0.83	1.015	32271.0	-1.143	0.254	268	0.63	0.965	268	0.86	1.022	31165.0	-2.962	0.003
Patella	28	Base of anterior surface	274	0.96	1.198	269	1.21	1.231	32807.5	-2.391	0.017	266	0.92	1.156	263	1.14	1.221	31403.5	-2.204	0.028

N) - number of cases used in the analysis; a) – mean score of ordinal variable; b) – standard deviation; p*) - two-tailed Monte Carlo significance test.

Table 46 – DMSM frequency results (sex-sub-sample) and Chi-square statistical test results.

			Left side							Right side						
			Female		Male					Female		Male				
Bone	No.	Enthesis	n/N	%	n/N	%	$\chi^2_{(df=1)}$	P*	Cramer's *V*	n/N	%	n/N	%	$\chi^2_{(df=1)}$	P*	Cramer's *V*
Clavicle	1	Acromial extremity – *Trapezius muscle*	39/281	13.9	39/277	14.1	0.005	1	Not significant	31/277	11.2	31/275	11	0.001	1	Not significant
	2	Acromial extremity – *Deltoideus muscle*	73/284	25.7	59/278	21.2	1.570	0.233	Not significant	63/279	22.6	53/280	19	1.133	0.299	Not significant
	3	Impression for costoclavicular ligament	39/285	13.7	47/282	16.7	0.980	0.35	Not significant	22/282	7.8	62/291	21	20.877	1	0.191
Scapula	4	Corocoid process	29/273	10.6	27/257	10.5	0.002	1	Not significant	33/272	12.1	30/253	12	0.009	1	Not significant
	5	Acromion - *Deltoideus muscle*	23/249	9.2	20/241	8.3	0.135	0.751	Not significant	32/246	13	29/245	12	0.155	0.785	Not significant
	6	Acromion – *Trapezius muscle*	18/252	7.1	14/240	5.8	0.347	0.588	Not significant	18/246	7.3	18/246	7.3	<0.001	1	Not significant
Humerus	7	Surgical neck	60/295	20.3	69/282	24.5	1.416	0.272	Not significant	63/292	21.6	73/287	25	1.200	0.282	Not significant
	8	Greater tubercle	41/254	16.1	26/254	10.2	3.868	0.066	0.087	44/254	17.3	29/254	11	3.599	0.076	0.084
	9	Lesser tubercle	65/278	23.4	56/276	20.3	0.775	0.411	Not significant	76/279	27.2	72/280	26	0.167	0.702	Not significant
	10	Deltoid tuberosity	25/289	8.7	47/268	17.5	9.757	0.002	0.132	43/287	15	54/275	20	2.130	0.149	Not significant
	11	Lateral epicondyle	47/249	18.9	23/252	9.1	9.902	0.002	0.141	65/243	26.7	37/248	15	10.436	0.001	0.146
	12	Medial epicondyle	23/257	8.9	7/258	2.7	9.127	0.002	0.133	26/251	10.4	13/249	5.2	4.588	0.044	0.096
Radius	13	Radial tuberosity	65/286	22.7	87/284	30.6	4.555	0.037	0.089	61/281	21.7	77/285	27	2.163	0.144	Not significant
	14	Inter-osseous border - *Pronator teres* insertion	20/283	7.1	32/263	12.2	4.115	0.057	0.087	13/278	4.7	31/255	12	9.827	0.002	0.136
Ulna	15	Olecranon	6/260	2.3	18/266	6.8	6.004	0.02	0.107	19/254	7.5	32/262	12	3.244	0.078	0.079
	16	Ulna tuberosity	16/291	5.5	16/189	5.5	<0.000	1	Not significant	32/296	10.8	30/281	11	0.003	1	Not significant
Coxal	17	*Ischium* tuberosity	139/294	47.3	93/286	32.5	13.162	<0.001	0.151	134/294	45.6	101/289	35	6.845	0.011	0.108
	18	Iliac crest	131/287	45.6	110/26	41.7	0.884	0.39	Not significant	120/284	42.3	107/260	41	0.068	0.862	Not significant
Femur	19	Greater trochanter	128/294	43.5	85/289	29.4	12.544	<0.001	0.147	100/284	35.2	93/284	33	0.385	0.595	Not significant
	20	Gluteal tuberosity	111/294	37.8	96/292	32.9	1.526	0.227	Not significant	108/297	36.4	91/295	31	2.018	0.165	Not significant
	21	Linea aspera	77/300	25.7	92/295	31.2	2.228	0.146	Not significant	58/300	19.3	81/299	27	5.056	0.026	0.092
	22	Medial supracondylar line	15/298	5	12/297	4	0.339	0.694	Not significant	23/300	7.7	13/299	4.3	2.920	0.121	Not significant
Tibia	23	Anterior tuberosity	37/287	12.9	98/290	33.8	35.159	<0.001	0.247	38/294	12.9	97/291	33	34.313	1	0.242
	24	Soleal line	85/300	28.3	72/296	24.3	1.234	0.306	Not significant	79/296	26.7	88/297	30	0.634	0.465	Not significant
	25	Fibular notch	26/289	9	22/288	7.6	0.349	0.652	Not significant	31/288	10.8	21/292	7.2	2.267	0.147	Not significant
Calcaneus	26	Posterior surface of calcaneus	122/250	48.8	88/256	34.4	10.841	0.001	0.146	126/257	49	96/262	37	8.131	0.005	0.125
	27	Plantar surface	70/257	27.2	64/265	24.2	0.651	0.425	Not significant	75/268	28	49/268	18	7.092	0.010	0.115
Patella	28	Base of anterior surface	117/267	43.8	93/276	33.7	5.866	0.017	0.104	105/264	39.8	85/268	32	3.760	0.058	0.084

n) - number of individuals with moderate to severe lesions; N) - total number of individuals observed; p*) - two-tailed Monte Carlo significance test.

Table 47 – Wilcoxon signed rank test results: bilateral significant differences for the upper and lower limb per sex sub-sample.

Upper limb			Females			Males		
Bone	No.	Enthesis	Z - score	P*	Side dominance	Z - score	P*	Side dominance
Clavicle	1	Acromial extremity – *Trapezius muscle*	-1.198	0.251	Not significant	-1.891	0.059	Not significant
	2	*Deltoideus muscle*	-0.794	0.417	Not significant	-0.266	0.794	Not significant
	3	Impression for costoclavicular ligament	-2.908	0.003	Left > Right	-0.956	0.340	Not significant
Scapula	4	Corocoid process	-0.473	0.642	Not significant	-0.243	0.832	Not significant
	5	Acromion - *Deltoideus muscle*	-2.421	0.016	Right > Left	-1.859	0.090	Not significant
	6	Acromion – *Trapezius muscle*	-0.800	0.471	Not significant	-1.300	0.265	Not significant
Humerus	7	Surgical neck	-0.115	0.951	Not significant	-2.785	0.005	Right > Left
	8	Greater tubercle	-1.680	0.097	Not significant	-1.040	0.309	Not significant
	9	Lesser tubercle	-2.816	0.005	Right > Left	-0.472	0.611	Not significant
	10	Deltoid tuberosity	-3.846	<0.001	Right > Left	-2.719	0.007	Right > Left
	11	Lateral epicondyle	-4.658	<0.001	Right > Left	-3.313	0.001	Right > Left
	12	Medial epicondyle	-1.769	0.081	Not significant	-2.033	0.052	Not significant
Radius	13	Radial tuberosity	-0.258	0.802	Not significant	-0.643	0.505	Not significant
	14	Inter-osseous border - Pronator teres insertion	-2.839	0.006	Left > Right	-0.099	0.974	Not significant
Ulna	15	Olecranon	-3.192	0.001	Right > Left	-2.397	0.016	Right > Left
	16	Ulna tuberosity	-4.199	<0.001	Right > Left	-2.768	0.006	Right > Left

Lower limb			Females			Males		
Bone	No.	Enthesis	Z - score	P*	Side dominance	Z - score	P*	Side dominance
Coxal	17	*Ischium* tuberosity	-0.755	0.433	Not significant	-0.589	0.570	Not significant
	18	Iliac crest	-2.983	0.003	Left > Right	-1.375	0.202	Not significant
Femur	19	Greater trochanter	-1.811	0.070	Not significant	-1.295	0.196	Not significant
	20	Gluteal tuberosity	-0.771	0.424	Not significant	-0.563	0.642	Not significant
	21	Linea aspera	-3.748	<0.001	Left > Right	-2.883	0.005	Left > Right
	22	Medial supracondylar line	-1.940	0.051	Not significant	-0.685	0.513	Not significant
Tibia	23	Anterior tuberosity	-0.171	0.908	Not significant	-0.923	0.365	Not significant
	24	Soleal line	-0.634	0.550	Not significant	-0.947	0.343	Not significant
	25	Fibular notch	-1.788	0.078	Not significant	-1.095	0.300	Not significant
Calcaneus	26	Posterior surface of calcaneus	-1.450	0.157	Not significant	-1.687	0.099	Not significant
	27	Plantar surface	-0.136	0.899	Not significant	-3.029	0.002	Left > Right
Patella	28	Base of anterior surface	-0.940	0.358	Not significant	-1.175	0.248	Not significant

P* - two-tailed Monte Carlo significance test.

6.2.5 MSM: analysis according to age at death

Kendall's tau_b correlation results showed that age and MSM had a significant association, with the exception of the costoclavicular ligament on the right clavicle (r=-0.034, p=0.309) and the greater trochanter on the right femur (r=0.017, p=0.586). The strength of the correlation, positive for all entheses, varied from weak (r=0.155, p<0.001) on the left femur's medial supracondylar line, to strong (r=0.572, p<0.001) on the right os coxa *ischium* tuberosity. Overall, the majority of the correlation strength was moderate (Table 48). The correlation between age and MSM degrees was further appraised using the Jonckheere-Terpstra statistical test (Table 15 ;Appendix_MSM). The results confirmed the highly statistical significance between age and MSM degrees (p<0.001), with the exception of the costoclavicular ligament on the right clavicle (p=0.307) and the greater trochanter on the right femur (p=0.586), as already observed in the Kendall's tau_b results. Overall, as the degree of lesions increased so did the mean age at death of individuals; mean age significant differences were mostly found between younger individuals with no lesion, and individuals with a moderate or strong degree of lesion (detailed description Table 15 and Figure 1; Appendix_MSM). The distribution of individuals according to age at death was similar, in all entheses observed: that is, the absence of lesions was associated with younger individuals

Table 48 - Kendall's tau_b correlation results: correlation between age and upper and lower MSM.

Upper limb			Left side			Right side		
Bone	N.	Entesis	N	Kendall's tau_b	p	N	Kendall's tau_b	p
Clavicle	1	Acromial extremity – *Trapezius muscle*	558	0.372	<0.001	552	0.303	<0.001
	2	Acromial extremity - *Deltoideus muscle*	562	0.414	<0.001	559	0.326	<0.001
	3	Impression for costoclavicular ligament	567	0.289	<0.001	573	-0.034	0.309
Scapula	4	Corocoid process	530	0.364	<0.001	525	0.404	<0.001
	5	Acromion - *Deltoideus muscle*	490	0.271	<0.001	491	0.344	<0.001
	6	Acromion *Trapezius muscle*	492	0.252	<0.001	492	0.307	<0.001
Humerus	7	Surgical neck	577	0.43	<0.001	579	0.425	<0.001
	8	Greater tubercle	508	0.396	<0.001	508	0.404	<0.001
	9	Lesser tubercle	554	0.482	<0.001	559	0.458	<0.001
	10	Deltoid tuberosity	557	0.302	<0.001	562	0.37	<0.001
	11	Lateral epicondyle	501	0.435	<0.001	491	0.464	<0.001
	12	Medial epicondyle	515	0.246	<0.001	500	0.331	<0.001
Radius	13	Radial tuberosity	570	0.434	<0.001	566	0.478	<0.001
	14	Inter-osseous border - *Pronator teres* insertion	546	0.41	<0.001	533	0.348	<0.001
Ulna	15	Olecranon	526	0.161	<0.001	516	0.241	<0.001
	16	Ulna tuberosity	580	0.29	<0.001	577	0.326	<0.001

Upper limb			Left side			Right side		
Bone	N.	Entesis	N	Kendall's tau_b	p	N	Kendall's tau_b	p
Coxal	17	*Ischium* tuberosity	580	0.524	<0.001	583	0.572	<0.001
	18	Iliac crest	551	0.489	<0.001	544	0.473	<0.001
Femur	19	Greater trochanter	583	0.497	<0.001	568	0.017	0.586
	20	Gluteal tuberosity	586	0.483	<0.001	592	0.474	<0.001
	21	Linea aspera	595	0.428	<0.001	599	0.399	<0.001
	22	Medial supracondylar line	595	0.155	<0.001	599	0.213	<0.001
Tibia	23	Anterior tuberosity	577	0.253	<0.001	585	0.214	<0.001
	24	Soleal line	596	0.242	<0.001	593	0.282	<0.001
	25	Fibular notch	577	0.212	<0.001	580	0.234	<0.001
Calcaneus	26	Posterior surface of calcaneus	506	0.364	<0.001	519	0.333	<0.001
	27	Plantar surface	522	0.289	<0.001	536	0.301	<0.001
Patella	28	Base of anterior surface	543	0.387	<0.001	529	0.379	<0.001

p?- two-tailed Monte Carlo significance test.

and a rise in MSM severity with older ones (Figure 40). There were a few exceptions contradicting this overall pattern, in which younger individuals would have lesions, and older individuals not.

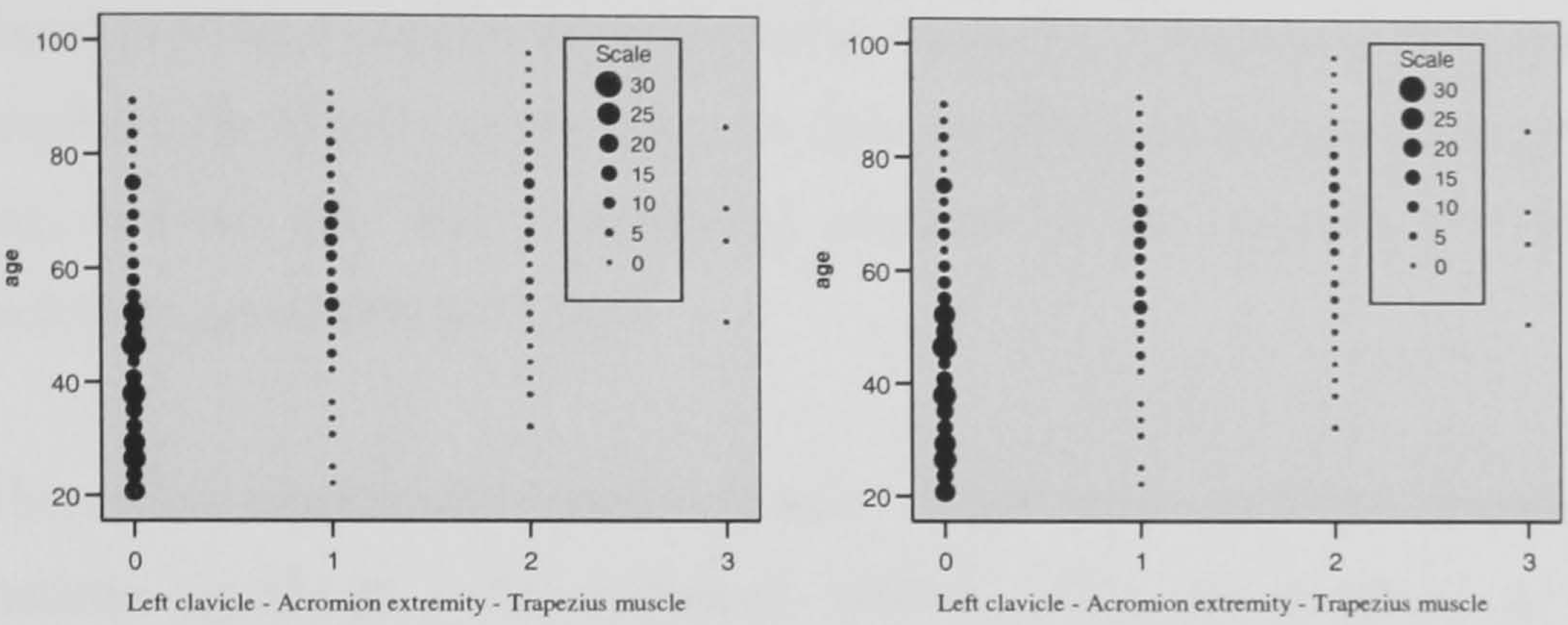

Figure 40– Scatterplot of age and MSM degrees in the acromion extremity of the clavicles.

6.2.6 DMSM: logistic regression analysis

The importance of sex and age as predictors, in the outcome of DMSM, were tested using logistic regression. Results of the tests can be found in Tables 49 to 52. Left and right side results are presented separately as well as upper and lower limb.

The results showed that the addition of the variables either sex and age, or both, to the baseline model, has proven to be statistically significant in all cases with the exception of the model for the right femur's greater trochanter ($\chi^2_{(2)}$=0.391, p=0.822). In this case the Wald statistic for both predictors was non-significant (sex=0.355, p=0.551; age=0.007, p=0.935).

Age revealed to be a significant predictor, as shown by the Wald statistics results ($p<0.05$) for DMSM in all entheses tested. Consistently, the value of *exp β* for age indicated that as the value of age increased (by one), the odds of having DMSM would also increase. Furthermore, because the confidence interval did not cross 1, the relationship between outcome variable (DMSM) and predictor (age), established in these models, would be found in 95% of samples from the same population. Contrary to the pattern mentioned, the results of the Wald's statistics for the right clavicle's costoclavicular ligament revealed that sex, and not age, was a significant predictor in the outcome of DMSM (sex=18.085, $p<0.001$; age=0.898, $p=0.343$).

There were other models were both sex and age were significant predictors, as the Wald's statistic significant values indicated ($p<0.05$). This was observed at the left clavicle's costoclavicular ligament; left and right humeri' surgical necks; right humerus' lesser tubercle; deltoid tuberosity of both humeri; left humerus' medial epicondyle; radial tuberosity and *Pronator teres* insertion of both radii; left and right ulnae's olecranons; *linea aspera* of both femurs; anterior tuberosity of tibiae; right tibia's soleal line and left calcaneus' posterior surface. In all theses cases the confidence interval ($CI_{95\%}$) did not cross 1, therefore similar results could be found in 95% of samples from the same population. Overall, upper right and left, and lower right and left limbs had similar results regarding which predictors were significant.

Assessment of the validity of the models was done using the Hosmer-Lemeshow goodness-of-fit test statistic (H&L). Whenever statistical significant, it would be indicative of a significant difference between predicted values (of a model) and those observed in the data; consequently, all considerations drawn from these models should be interpreted with caution. Statistical significant H&L results ($p<0.05$) were found for the humerii greater tubercule; right humerus' lateral epicondyle; and *ischium* tuberosity of the *os* coxae, although in the left *os* coxa *ischium* tuberosity p-value (=0.051) was barely significant; iliac crest of the *os coxae*; gluteal tuberosity of the right femur, and finally both left and right posterior surface of the calcaneii and the base of the anterior surface of the *patellae*. In the remaining cases, the H&L goodness-of-fit results were non-significant ($p>0.05$), therefore the models were predicting the data fairly well.

The overall success rate of classification of the models varied considerable. Generally, the percentage of success varied from moderate (above 50%) to high (90% or more). However, there were several cases where the models failed to accurately predict any case of positive DMSM (see values of sensitivity of prediction), and blindly attributed all cases to the category of absence of DMSM (see values of specificity of prediction). The models concerning the lower limb had lower overall successful rates, but they were more capable of predicting a reasonable percentage of DMSM (see values of sensitivity and specificity of prediction).

Table 49 – DMSM logistic regression results: left upper limb.

Bone	N	Enthesis	Predictors	B	S.E	Wald (d.f. =1)	p	Exp(B)	95.0% C.I. for EXP(B) Lower	95.0% C.I. for EXP(B) Upper	Log-likelihood statistic $\chi^2_{(df=2)}$	Log-likelihood statistic p	H & L goodness-of-fit statistic $\chi^2_{(df=8)}$	H & L goodness-of-fit statistic p	R^2 Cox & Snell	R^2 Nagelkerke	Sensitivity of prediction %	Specificity of prediction %	Overall success rate %
Clavicle	1	Acromial extremity – *Trapezius muscle*	Sex	-0.475	0.271	3.076	0.079	0.622	0.366	1.057	63.09	<0.001	7.732	0.46	0.107	0.193	3.8	100	86.6
			Age	0.059	0.008	48.911	0.000	1.061	1.043	1.079									
			Constant	-5.093	0.545	87.467	0.000	0.006											
	2	Acromial extremity – *Deltoideus muscle*	Sex	-0.163	0.225	0.523	0.469	0.850	0.546	1.321	97.773	<0.001	10.49	0.232	0.16	0.241	32.5	93.5	77
			Age	0.060	0.007	73.729	0.000	1.062	1.047	1.076									
			Constant	-4.563	0.436	109.675	0.000	0.010											
	3	Impression for costoclavicular ligament	Sex	-0.638	0.258	6.109	0.013	0.528	0.318	0.876	56.084	<0.001	2.068	0.979	0.094	0.164	1.2	99.8	84.8
			Age	0.052	0.008	45.033	0.000	1.054	1.038	1.070									
			Constant	-4.461	0.488	83.554	0.000	0.012											
Scapula	4	Coracoid process	Sex	-0.277	0.300	0.852	0.356	0.758	0.421	1.365	35.983	<0.001	9.406	0.309	0.066	0.134	0	100	89.4
			Age	0.051	0.009	29.661	0.000	1.052	1.033	1.071									
			Constant	-5.023	0.613	67.124	0.000	0.007											
	5	Acromion - *Deltoideus muscle*	Sex	-0.236	0.340	0.480	0.488	0.790	0.405	1.539	24.637	<0.001	1.996	0.981	0.049	0.109	0	100	91.2
			Age	0.048	0.010	20.783	0.000	1.049	1.027	1.070									
			Constant	-5.039	0.673	56.027	0.000	0.006											
	6	Acromion – *Trapezius muscle*	Sex	-0.069	0.385	0.032	0.858	0.934	0.439	1.985	13.519	0.001	4.765	0.782	0.027	0.071	0	100	93.5
			Age	0.039	0.011	11.704	0.001	1.040	1.017	1.063									
			Constant	-4.912	0.729	45.433	0.000	0.007											
Humerus	7	Surgical neck	Sex	-0.729	0.230	10.072	0.002	0.483	0.308	0.757	93.797	<0.001	11.676	0.166	0.15	0.229	20.2	96	79
			Age	0.060	0.007	70.917	0.000	1.062	1.047	1.076									
			Constant	-4.366	0.436	100.387	0.000	0.013											
	8	Greater tubercle	Sex	0.100	0.299	0.113	0.737	1.106	0.616	1.985	83.952	<0.001	19.626	0.012	0.152	0.281	6	97.5	85.4
			Age	0.078	0.011	54.879	0.000	1.081	1.059	1.104									
			Constant	-6.718	0.718	87.439	0.000	0.001											
Humerus	9	Lesser tubercle	Sex	-0.477	0.257	3.451	0.063	0.621	0.375	1.027	167.976	<0.001	8.456	0.39	0.262	0.402	37.2	92.8	80.7
			Age	0.095	0.010	98.875	0.000	1.100	1.079	1.120									
			Constant	-6.755	0.613	121.264	0.000	0.001											
	10	Deltoid tuberosity	Sex	-1.210	0.287	17.721	0.000	0.298	0.170	0.524	46.191	<0.001	3.659	0.887	0.08	0.148	0	99.8	86.9
			Age	0.046	0.008	31.010	0.000	1.047	1.030	1.065									
			Constant	-4.059	0.510	63.345	0.000	0.017											
	11	Lateral epicondyle	Sex	0.498	0.300	2.756	0.097	1.646	0.914	2.964	91.906	<0.001	10.954	0.204	0.168	0.302	11.4	96.5	84.6
			Age	0.075	0.010	56.590	0.000	1.078	1.057	1.099									
			Constant	-6.659	0.688	93.791	0.000	0.001											
	12	Medial epicondyle	Sex	1.011	0.452	5.005	0.025	2.747	1.133	6.658	27.854	<0.001	11.208	0.19	0.053	0.147	0	100	94.2
			Age	0.047	0.012	15.387	0.000	1.048	1.024	1.073									
			Constant	-6.219	0.841	54.746	0.000	0.002											
Radius	13	Radial tuberosity	Sex	-0.955	0.226	17.839	0.000	0.385	0.247	0.599	119.459	<0.001	3.912	0.865	0.189	0.275	32.9	90.4	75.1
			Age	0.065	0.007	85.664	0.000	1.067	1.052	1.081									
			Constant	-4.273	0.417	105.022	0.000	0.014											
	14	Interosseous border - Pronator teres insertion	Sex	-1.112	0.331	11.295	0.001	0.329	0.172	0.629	52.839	<0.001	9.304	0.317	0.092	0.198	0	99.8	90.3
			Age	0.064	0.011	36.453	0.000	1.067	1.045	1.089									
			Constant	-5.674	0.702	65.230	0.000	0.003											
Ulna	15	Olecranon	Sex	-1.515	0.504	9.025	0.003	0.220	0.082	0.591	19.399	<0.001	4.41	0.818	0.036	0.117	0	100	95.4
			Age	0.045	0.013	11.627	0.001	1.046	1.019	1.073									
			Constant	-5.085	0.829	37.613	0.000	0.006											
	16	Ulna tuberosity	Sex	-0.399	0.385	1.073	0.300	0.671	0.315	1.428	22.1	<0.001	11.665	0.167	0.037	0.108	0	100	94.5
			Age	0.050	0.012	18.395	0.000	1.052	1.028	1.076									
			Constant	-5.667	0.776	53.331	0.000	0.003											

Table 50 – DMSM logistic regression results: left lower limb.

Bone	N	Enthesis	Predictors	B	S.E	Wald (d.f. =1)	p	Exp(B)	95.0% C.I. for EXP(B) Lower	95.0% C.I. for EXP(B) Upper	Log-likelihood statistic $\chi^2_{(df=2)}$	Log-likelihood statistic p	H & L goodness-of-fit statistic $\chi^2_{(df=8)}$	H & L goodness-of-fit statistic p	R^2 Cox & Snell	R^2 Nagelkerke	Sensitivity of prediction %	Specificity of prediction %	Overall success rate %
Coxal	17	Isquial tuberosity	Sex	0.313	0.207	2.287	0.130	1.367	0.912	2.051	207.573	<0.001	15.422	0.051	0.301	0.407	63.4	83.3	75.3
			Age	0.079	0.007	130.053	0.000	1.082	1.067	1.097									
			Constant	-4.877	0.407	143.780	0.000	0.008											
	18	Iliac crest	Sex	-0.175	0.205	0.728	0.394	0.84	0.562	1.254	168.955	<0.001	40.156	<0.001	0.264	0.354	62.2	77.1	70.6
			Age	0.072	0.007	118.161	0.000	1.075	1.061	1.089									
			Constant	-4.098	0.381	115.861	0.000	0.017											
Femur	19	Great throcanter	Sex	0.306	0.212	2.080	0.149	1.358	0.896	2.058	216.026	<0.001	10.067	0.26	0.31	0.424	64.3	83.5	76.5
			Age	0.083	0.007	131.701	0.000	1.086	1.071	1.102									
			Constant	-5.346	0.438	148.835	0.000	0.005											
	20	Gluteal tuberosity	Sex	-0.209	0.205	1.040	0.308	0.811	0.542	1.213	163.322	<0.001	9.631	0.292	0.243	0.335	57.5	82.8	73.9
			Age	0.070	0.007	115.210	0.000	1.073	1.059	1.086									
			Constant	-4.412	0.386	130.397	0.000	0.012											
	21	Linea aspera	Sex	-0.836	0.217	14.907	0.000	0.433	0.283	0.663	125.85	<0.001	14.573	0.068	0.191	0.274	35.5	89	73.8
			Age	0.063	0.007	92.260	0.000	1.066	1.052	1.079									
			Constant	-4.142	0.391	112.214	0.000	0.016											
	22	Medial supracondilar line	Sex	-0.046	0.412	0.012	0.911	0.955	0.426	2.14	12.01	0.002	13.203	0.105	0.02	0.065	0	100	95.5
			Age	0.038	0.012	10.404	0.001	1.039	1.015	1.063									
			Constant	-5.250	0.764	47.194	0.000	0.005											
Tibia	23	Anterior tuberosity	Sex	-1.767	0.249	50.499	0.000	0.171	0.105	0.278	104.257	<0.001	12.942	0.114	0.165	0.249	28.1	95	79.4
			Age	0.051	0.007	56.151	0.000	1.052	1.038	1.066									
			Constant	-3.310	0.388	72.723	0.000	0.037											
	24	Soleal line	Sex	-0.029	0.198	0.021	0.883	0.971	0.659	1.431	46.846	<0.001	9.287	0.319	0.076	0.110	5.7	97.7	73.5
			Age	0.035	0.006	41.089	0.000	1.036	1.025	1.047									
			Constant	-2.983	0.332	80.507	0.000	0.051											
	25	Fibular notch	Sex	0.320	0.320	0.244	0.621	0.854	0.456	1.599	24.663	<0.001	8.037	0.43	0.042	0.096	0	100	91.7
			Age	0.043	0.009	20.928	0.000	1.044	1.025	1.063									
			Constant	-4.842	0.603	64.468	0.000	0.008											
Calcaneus	26	Posterior surface of calcaneus	Sex	0.421	0.200	4.437	0.035	1.524	1.03	2.256	97.935	<0.001	23.457	0.003	0.176	0.237	51.9	76.4	66.2
			Age	0.050	0.006	71.909	0.000	1.052	1.04	1.064									
			Constant	-3.240	0.346	87.545	0.000	0.039											
	27	Plantar surface	Sex	-0.090	0.217	0.174	0.677	0.914	0.597	1.398	62.166	<0.001	11.924	0.155	0.112	0.165	17.9	94.1	74.5
			Age	0.046	0.006	52.463	0.000	1.047	1.034	1.06									
			Constant	-3.556	0.382	86.510	0.000	0.029											
Patella	28	Base of anterior surface	Sex	0.172	0.200	0.739	0.390	1.187	0.803	1.755	120.598	<0.001	24.261	0.002	0.199	0.270	54.3	79	69.4
			Age	0.057	0.006	89.815	0.000	1.059	1.047	1.072									
			Constant	-3.669	0.356	106.142	0.000	0.026											

Table 51 – DMSM logistic regression results: right upper limb.

Bone	N	Enthesis	Predictors	B	S.E	Wald	p	Exp(B)	95.0% C.I. for EXP(B)		Log-likelihood statistic		H & L goodness-of-fit statistic		R^2	R^2	Sensitivity of prediction	Specificity of prediction	Overall success rate
						(d.f. =1)			Lower	Upper	$\chi^2_{(df=2)}$	p	$\chi^2_{(df=8)}$	p	Cox & Snell	Nagelkerke	%	%	%
Clavicle	1	Acromial extremity – *Trapezius muscle*	Sex	-0.275	0.283	0.940	0.332	0.760	0.436	1.324	20.926	<0.001	11.083	0.197	0.037	0.074	0	100	88.8
			Age	0.035	0.008	18.988	0.000	1.036	1.019	1.052									
			Constant	-3.930	0.498	62.303	0.000	0.020											
	2	**Acromial extremity – *Deltoideus muscle***	Sex	-0.045	0.223	0.041	0.839	0.956	0.617	1.48	48.196	<0.001	2.659	0.954	0.083	0.129	2.6	99.8	79.6
			Age	0.042	0.006	41.079	0.000	1.042	1.029	1.056									
			Constant	-3.672	0.400	84.073	0.000	0.025											
	3	Impression for costoclavicular ligament	Sex	-1.131	0.266	18.085	0.000	0.323	0.191	0.543	22.569	<0.001	11.622	0.169	0.039	0.068	0	100	85.3
			Age	-0.006	0.007	0.898	0.343	0.994	0.981	1.007									
			Constant	-0.990	0.360	7.556	0.006	0.372											
Scapula	4	Coracoid process	Sex	-0.387	0.295	1.727	0.189	0.679	0.381	1.21	55.363	<0.001	3.769	0.877	0.1	0.192	0	99.8	87.8
			Age	0.063	0.010	42.319	0.000	1.065	1.045	1.085									
			Constant	-5.610	0.640	76.725	0.000	0.004											
	5	Acromion - Deltoideus muscle	Sex	-0.266	0.296	0.811	0.368	0.766	0.429	1.368	40.44	<0.001	6.276	0.616	0.079	0.150	0	100	87.6
			Age	0.053	0.009	32.995	0.000	1.054	1.035	1.073									
			Constant	-4.953	0.595	69.386	0.000	0.007											
	6	Acromion – Trapezius muscle	Sex	-0.400	0.370	1.171	0.279	0.670	0.325	1.383	26.12	<0.001	6.355	0.608	0.052	0.127	0	100	92.7
			Age	0.054	0.012	21.346	0.000	1.055	1.031	1.08									
			Constant	-5.600	0.771	52.695	0.000	0.004											
Humerus	7	Surgical neck	Sex	-0.673	0.224	9.034	0.003	0.510	0.329	0.791	92.127	<0.001	12.094	0.147	0.147	0.222	22.1	95.5	78.2
			Age	0.058	0.007	70.871	0.000	1.060	1.045	1.074									
			Constant	-4.210	0.421	100.090	0.000	0.015											
	8	Greater tubercle	Sex	0.043	0.289	0.022	0.882	1.044	0.593	1.838	86.523	<0.001	21.919	0.005	0.157	0.279	9.6	97.7	85
			Age	0.076	0.010	57.168	0.000	1.079	1.058	1.101									
			Constant	-6.448	0.678	90.336	0.000	0.002											
Humerus	9	Lesser tubercle	Sex	-0.565	0.239	5.571	0.018	0.569	0.356	0.909	174.056	<0.001	5.447	0.709	0.268	0.390	48.6	88.8	78.2
			Age	0.088	0.008	108.227	0.000	1.092	1.074	1.11									
			Constant	-5.926	0.525	127.570	0.000	0.003											
	10	Deltoid tuberosity	Sex	-0.726	0.248	8.590	0.003	0.484	0.298	0.786	60.059	<0.001	12.017	0.15	0.101	0.169	3.1	98.9	82.4
			Age	0.051	0.007	47.429	0.000	1.052	1.037	1.068									
			Constant	-4.202	0.462	82.593	0.000	0.015											
	11	Lateral epicondyle	Sex	0.478	0.255	3.520	0.061	1.614	0.979	2.66	102.576	<0.001	19.428	0.013	0.189	0.295	25.5	92	78.2
			Age	0.070	0.009	66.957	0.000	1.072	1.054	1.09									
			Constant	-5.694	0.562	102.582	0.000	0.003											
	12	Medial epicondyle	Sex	0.402	0.372	1.167	0.280	1.494	0.721	3.096	41.71	<0.001	5.562	0.696	0.08	0.190	0	100	92.2
			Age	0.064	0.012	28.011	0.000	1.066	1.041	1.092									
			Constant	-6.607	0.835	62.546	0.000	0.001											
Radius	13	Radial tuberosity	Sex	-1.005	0.245	16.837	0.000	0.366	0.226	0.592	150.698	<0.001	9.28	0.319	0.234	0.349	40.6	91.1	78.8
			Age	0.081	0.008	97.745	0.000	1.084	1.067	1.102									
			Constant	-5.457	0.504	117.070	0.000	0.004											
	14	Interosseous border - Pronator teres insertion	Sex	-1.541	0.373	17.044	0.000	0.214	0.103	0.445	46.003	<0.001	3.471	0.901	0.083	0.190	0	100	91.7
			Age	0.059	0.011	28.435	0.000	1.061	1.038	1.084									
			Constant	-5.320	0.716	55.146	0.000	0.005											
Ulna	15	Olecranon	Sex	-1.016	0.333	9.309	0.002	0.362	0.189	0.695	44.268	<0.001	8.841	0.356	0.082	0.173	0	100	90.1
			Age	0.058	0.010	32.862	0.000	1.060	1.039	1.081									
			Constant	-5.246	0.656	63.899	0.000	0.005											
	16	Ulna tuberosity	Sex	-0.524	0.299	3.066	0.080	0.592	0.329	1.065	64.199	<0.001	14.341	0.073	0.105	0.213	1.6	100	89.4
			Age	0.068	0.010	46.743	0.000	1.071	1.05	1.092									
			Constant	-6.033	0.667	81.826	0.000	0.002											

Table 52 – DMDM logistic regression results: right lower limb.

Bone	N	Enthesis	Predictors	B	S.E	Wald	p	Exp(B)	95.0% C.I. for EXP(B)		Log-likelihood statistic		H & L goodness-of-fit statistic		R^2	R^2	Sensitivity of prediction	Specificity of prediction	Overall success rate
						(d.f. =1)			Lower	Upper	$\chi^2_{(df=2)}$	p	$\chi^2_{(df=8)}$	p	Cox & Snell	Nagelkerke	%	%	%
Coxal	17	Isquial tuberosity	Sex	0.014	0.214	0.005	0.947	1.014	0.667	1.544	239.485	<0.001	26.17	0.001	0.337	0.455	68.9	84.2	78
			Age	0.090	0.008	142.323	0.000	1.094	1.078	1.111									
			Constant	-5.374	0.439	149.540	0.000	0.005											
	18	Iliac crest	Sex	-0.337	0.205	2.705	0.100	0.714	0.477	1.067	148.039	<0.001	30.728	<0.001	0.238	0.321	59.9	76.7	69.7
			Age	0.067	0.006	108.006	0.000	1.069	1.056	1.083									
			Constant	-3.821	0.369	107.409	0.000	0.022											
Femur	19	Great throcanter	Sex	0.107	0.180	0.355	0.551	1.113	0.782	1.584	0.391	0.822	8.35	0.4	0.001	0.001	0	100	66
			Age	0.000	0.005	0.007	0.935	1.000	0.991	1.01									
			Constant	-0.739	0.268	7.597	0.006	0.478											
	20	Gluteal tuberosity	Sex	-0.146	0.201	0.530	0.467	0.864	0.583	1.281	135.457	<0.001	21.885	0.005	0.205	0.284	50.3	84.5	73
			Age	0.062	0.006	100.641	0.000	1.064	1.051	1.077									
			Constant	-4.096	0.370	122.331	0.000	0.017											
	21	Linea aspera	Sex	-0.959	0.226	17.928	0.000	0.383	0.246	0.598	99.062	<0.001	10.47	0.234	0.152	0.230	18.7	93.7	76.3
			Age	0.058	0.007	73.188	0.000	1.060	1.046	1.074									
			Constant	-4.090	0.408	100.540	0.000	0.017											
	22	Medial supracondilar line	Sex	0.294	0.372	0.624	0.430	1.341	0.647	2.781	22.234	<0.001	13.956	0.083	0.036	0.100	0	100	94
			Age	0.043	0.011	16.533	0.000	1.044	1.023	1.066									
			Constant	-5.490	0.708	60.055	0.000	0.004											
Tibia	23	Anterior tuberosity	Sex	-1.594	0.236	45.515	0.000	0.203	0.128	0.323	77.704	<0.001	12.069	0.148	0.124	0.188	20	96.9	79.1
			Age	0.039	0.006	37.717	0.000	1.039	1.027	1.052									
			Constant	-2.677	0.358	56.080	0.000	0.069											
	24	Soleal line	Sex	-0.422	0.197	4.594	0.032	0.656	0.446	0.965	50.34	<0.001	7.979	0.435	0.081	0.117	9.6	94.8	70.8
			Age	0.037	0.006	44.388	0.000	1.037	1.026	1.049									
			Constant	-2.764	0.324	72.925	0.000	0.063											
	25	Fibular notch	Sex	0.087	0.313	0.076	0.782	1.090	0.59	2.015	35.182	<0.001	6.877	0.55	0.059	0.130	0	100	91
			Age	0.049	0.009	27.272	0.000	1.050	1.031	1.069									
			Constant	-5.270	0.616	73.119	0.000	0.005											
Calcaneus	26	Posterior surface of calcaneus	Sex	0.308	0.195	2.484	0.115	1.360	0.928	1.995	91.854	<0.001	24.124	0.002	0.162	0.218	54.1	76.4	66.9
			Age	0.049	0.006	70.004	0.000	1.050	1.038	1.063									
			Constant	-3.071	0.339	82.032	0.000	0.046											
	27	Plantar surface	Sex	0.308	0.222	1.929	0.165	1.360	0.881	2.101	57.739	<0.001	10.538	0.229	0.102	0.154	10.5	97.3	77.2
			Age	0.042	0.006	43.983	0.000	1.043	1.03	1.056									
			Constant	-3.736	0.395	89.557	0.000	0.024											
Patella	28	Base of anterior surface	Sex	0.086	0.204	0.178	0.674	1.090	0.731	1.624	110.175	<0.001	23.864	0.002	0.187	0.257	45.3	80.4	67.9
			Age	0.056	0.006	84.233	0.000	1.058	1.045	1.071									
			Constant	-3.707	0.364	103.718	0.000	0.025											

6.2.7 MSM and DMSM: summary of results

The degree of severity of MSM was higher in the lower than in the upper limbs, as well as the presence of DMSM. When DMSM were analysed the number of individuals with lesions was significantly lower than when MSM were considered. For both, bilateral asymmetry clarified the presence of right side dominance, although in some cases the difference found between right and left lesions were only slightly more severe on the right side. A few cases of left dominance were also found. The LLSC presented higher mean scores of severity (MSM), and higher probabilities of developing more severe lesions (DMSM) than the CISC. Overall right side dominance was preserved in the collections sub-sample.

Both for MSM and DMSM no clear sex-specific pattern was found, however, on average, women had higher mean scores (MSM), as well as higher probabilities of exhibiting more severe lesions (DMSM) when compared to men. In general, right side dominance was observed in the sex sub-samples.

Strong correlations with age were found in the MSM variables. In DMSM variables age continued to be a significant predictor in the outcome of severe lesions, with sex being significant in some cases, both in the upper as well as lower limbs.

6.3 Discussion of DBC, OA and MSM results

The discussion of this section will focus on the importance of redefining the methods to evaluate DBC, OA and MSM in human archaeological remains. The results will therefore be discussed, not to interpret the outcome of the statistical analysis from an historical/geographical (skeletal collections), sexual or chronological (age-at-death) point of view, but to expose some of the difficulties and contradictions of the methods employed in the bioarchaeological analysis of the bony changes,[58] analysed in this research. Whenever necessary individual references will be made to particular bony changes. Finally, an alternative to the discussed approach to DBC, OA and MSM will be introduced. The purpose of this section is, partially, to justify the second set variables created for the analysis of gender in palaeopathology in this research, and to provide a basic framework for further discussion of bioarchaeological methods of analysis.

6.3.1 Difficulties and contradictions in bioarchaeological analysis of DBC, OA and MSM

One of the major drawbacks of bioarchaeological analysis of degenerative bony changes observable in the skeletons which remains, is the inconsistency of the methods used in recoding those bony changes. Although bioarchaeologists have been systematic in the observations of the skeletal changes under examination, there is a lack of consistency in the interpretation of the results. The current study has clearly shown that a researcher's approach to his/her data may heavily influence the results obtained. The results provided are not wrong, but simply express a particular point of view, or research approach, instead of representing a general view about a particular bony change.

The variability in methods used to assess OA and MSM is one of the major difficulties in bioarchaeology, as already discussed in Chapter 3. Additionally, personal preference, experience and academic background are particularly expressed in the selection of criteria to assess OA and MSM, statistical analyses, and interpretation of the data. The results presented throughout the analysis in this chapter exemplify this. As introduced in the Chapter 3, although bioarchaeologist's can easily distinguish what to record, they may not have the necessary awareness, knowledge and experience to know the best way to address the data properly. Many may disagree with these observations, but one should consider the

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[58] The relevance of the historical/geographical (skeletal collections), sexual, chronological (age-at-death) and occupational background of the individual, as predictors on the outcome of the bone changes under analysis will be addressed in the final discussion (Chapter 8).

position of an undergraduate or even graduate student, beginning a career. How aware of the "contradictions" and "difficulties" that exist within bioarchaeological analysis is a newcomer or a beginner to the discipline? And if one was more aware of the actual state of the discipline, how critical would one have been? Personally, between colleagues and friends, the discussion about the need for improvement in the discipline, specifically its methods of recording and analysis, has been constant and vivid. The only way to bring that discussion to the core of the discipline, and start from the basics again, is to encourage constructive discussion amongst the "dinosaurs" and "neophytes" of the speciality, without fear of criticism and/or to criticise. After all, scientific advancement is made through trial and error.

6.3.2 Variability in scoring, grouping data and testing bony changes

The multitude of methods available to infer similar bony changes confuses and distresses many bioarchaeologists. For instance, in the specific case of OA studies, occasionally OA and DBC (such as marginal lipping, porosity and eburnation) are used interchangeably, that is, diagnostic criteria and diagnosed pathology are employed synonymously. For instance, on the one hand Merbs (1983) assesses OA based on the presence of any of the DBC. The existence of osteophytes, porosity and eburnation was enough to diagnose OA. On the other hand, the main and most globally used method of OA diagnosis does not use DBC, osteophytes, porosity and eburnation individually in the assessment of OA. The sole exception is applicable to eburnation which is considered to be pathognomonic of OA (Rogers and Waldron, 1995; Rogers *et al.*, 1987). This is one of the contradictions found whilst analysing OA in bioarchaeological contexts. Hence, as DBC and OA are randomly used as both diagnostic criteria and as diagnosis, their use together is an unfortunate oxymoron.

In the current research, results of both individual DBC and OA diagnosis were presented. The major conclusion was that the use of DBC and OA gave clearly distinct results. The number of joints affected with individual DBC is occasionally more than double the cases of OA. This is particularly true for marginal lipping. It was also possible to ascertain that DBC lesions were significantly higher in the right side joints, whilst, when OA was considered, the results only allowed to determine if the bilateral association was significant, without side reference. These results are intimately related with the nature of the data. That is, based on the methods used for diagnosis, OA was a condition of rare occurrence. Therefore bilateral associations found were mostly related with the absence of pathology rather than with its presence (see results on section 6.1.2).

The presence of statistically significant differences between men and women was found in several DBC and articular surfaces. However, when OA was examined only the knee joint revealed statistically significant sex association. Nevertheless, regardless of the results being statistically significant or not, in general women exhibited higher levels of lesions, as well as probabilities of developing DBC and OA. Increasing age was of major importance for the presence of any type of DBC, as well as OA. This was the only constant variable throughout all the statistical analysis performed, reiterating its extreme importance in explaining the outcome of these degenerative lesions. Of course, some exceptions were found as some young individuals exhibited DBC and OA, whilst older individuals showed no indications of DBC and OA (see Appendix_DBC, Table 14, for details).

With the analysis of MSM and DMSM the results encountered fit those found for DBC and OA. That is, if the data were analysed considering the cases with moderate to severe lesions, defined by the variable DMSM, the number of cases was considerably lower when compared to the analysis of the ordinal variable which expressed values of lesions between 0 and 3. Most of the severe lesions were found on the right side. A bilateral association was also found with DMSM; lesions were severe and more probable in women than in men; and finally, MSM and DMSM were highly associated with age.

The above paragraphs are illustrative of the importance of standardization of the methods used in recording and analysis, especially if one's objective is to compare the data with those of other studies. Without a clear description of the methods employed, comparisons between populations should not be undertaken, or if such a situation was to happen, only generalised considerations could be drawn, even though one should aim to discourage universal conclusions in bioarchaeological studies. This is another of the issues that needs to be addressed in the discipline. As already widely discussed in Chapter 3, any bioarchaeological study should be contextualized, and any results drawn from bioarchaeological analysis should consider the population's chronological and geographical context.

6.3.2.1 Which diagnostic criteria should be used in OA assessment?

The "non-use" of osteophytes in OA diagnosis, referred to as marginal lipping in this research, is related to the fact that, on their own, these changes may be solely age related. The fact that the joints can be classified as pathological only in the presence of other lesions, such as eburnation, porosity and sclerosis, has given osteophytes a secondary role (Rogers *et al.*, 1987). However, the approach to osteophytes in clinical analysis is that they are an integral aspect of OA, and should be included in its study (Van der Kraan and Van der Berg, 2006). In reality, osteophytes have been consistently used in clinical analysis since the systematic radiological assessment proposed by Kellgren and Lawrence (1957a, 1957b).

Exclusion of osteophytes based on their association with age may not be a reasonable argument for their exclusion from bioarchaeological record. This is particularly true because in the current research it is not only marginal lipping/osteophytes that correlate with age. All DBC and MSM were proven to be highly associated with age (sections: 6.1.1.4; 6.1.2.4; 6.2.5). Hence, they all behave in a similar way with regard to the age of the individuals. If one disregards a particular DBC based on the age-correlation assumption, whilst other indicators of disease are present, perhaps one should apply the same rule to all DBC. At this stage the aetiology of OA/DBC is considered to be vast, so a precautionary attitude would be the best one. Although, osteophytes have consistently been ruled as primarily correlated with biological age, therefore unreliable in OA assessment/diagnosis (Rogers and Waldron, 1995; Rogers *et al.*, 1987; Weiss and Jurmain, 2007), new clinical data has considered and proven that osteophyte formation is an integral component of OA (Hart and Spector, 2003; Van der Kraan and Van der Berg, 2006; only to name a few). Though many of the studies are location specific, particularly the knee, the findings that osteophytes are an integral component of OA should be brought to bioarchaeological analysis. Joint specific or not, bioarchaeology should try to account for osteophytes as an integral component of OA.

The age-forming approach to osteophytes in bioarchaeology may be an oversimplified justification in much of the research done so far. Cases of old individuals without bony changes and young individuals with osteophytic changes contribute to this discussion (Chu and Thornhill, 2001). In fact, the current research is an illustrative example of that situation. Although statistical significance was achieved for age in all variables analysed, the presence of outliers is irrefutable, making even more important the control for age-at-death variable in this sample, and in any populational study. Barely marginal osteophytes were found in individuals in their second decade of life, and sharp ridged osteophytes in individuals as young as 30 years old. The age at death for individuals with OA ranged from 24 years (right wrist) to 98, in many of the joints (see Table 14 in Appendix_DBC).

On the other end of OA diagnosis we find eburnation. Its use as sole criteria of OA identification excludes the effect of many other DBC, particularly marginal lipping, which is the most frequent change observed in the current research. The advantage of only using this type of change relies on its easy recognition, rendering inter-population comparisons feasible and without much intra and inter-observer error. However, this conservative approach disregards all the remaining degenerative lesions that affect articular surfaces. Its unique presence is therefore hardly representative of the quantitative and qualitative magnitude of changes observed in the joints. Furthermore, because of the degree of severity attibuted to eburnation, as the "final result" of OA, one may be looking at the final stage of a long developmental process. Therefore, to consider solely eburnation is to overlook the developmental history of OA. The chronology of degenerative progression on joints may not be completely known, but in bioarchaeology it is assumed that the majority of changes would eventually lead to eburnation in the living, as a disease progression sign. Then again, perhaps this is also an assumption that needs revision. In summary, this monocular view on articular changes overlooks the overall evolution of the changes in an individual, and population at large. It tends to forgo the fact that different joints may display different articular changes, as well as degrees of changes depending on as many factors as sex, age, genetics, morphology, body weight and others.

The major consequence of the selection of the criteria for diagnosis of OA in bioarchaeology is the drastic reduction in number of cases accounted for. The obvious conclusion was that, if one was to use the method described by Rogers and colleagues (1987, 1995), one would have to exclude many of the bony changes present in the human skeletal remains studied in this research. In some cases, some of the changes were exuberant (specifically in the case of marginal lipping), but because these were not found in the presence of any other DBC, the joints affected with these DBC were not considered in the final OA analysis. This approach is indeed conservative but it passes over an enormous amount of changes. The idea that just one change can be associated with OA may overlook, to a certain extent, the concept of OA as a disease of the joint (Felson and Neogi, 2004). The reality is that, *in vivo,* the DBC induced by OA can affect the periarticular zone and muscles and ligaments, and these changes can be accounted for from a bioarchaeological perspective. In the clinical data, OA may also affect the synovium as well as the neurosensory system (Felson and Neogi, 2004).

Another consideration in the bioarchaeological analysis of OA, the anatomical compartments of a particular joint, considered for OA analysis may vary, the most particular case is that of the shoulder. For instance, in the current research the inclusion of the acromioclavicular joint, as part of the shoulder joint, significantly increased the number of OA cases, when compared to the shoulder joint where only the glenoid cavity and humeral head were considered (left shoulder with acromioclavicular compartment=22.5% cases *versus* 13.1% cases without acromioclavicular compartment; see section 6.1.2.1 for details). This was observed in the current research, and was also referred to by Bridges (1993). The acromioclavicular joint compartment revealed to have more cases of eburnation than the glenoid cavity or humeral head, thus contributing to the overall number of cases diagnosed as OA. These results can also be used to reinforce the fact that joints behave differently, and can therefore develop dissimilar, and various, degrees of DBC.

The above mentioned situation contributes to emphasise the importance of individual joint morphology in the development of OA. For instance, recent studies have showed that obesity may be an important risk factor in the development of OA of the knee, but not of the hip (Reijman *et al.*, 2007). In this case specific joint morphology, its alignment (in this specific case of the knee) as well as limb length inequality may be responsible for the risk-specific association found between the onset of OA in the hip and knee (Felson *et al.*, 2000;

Felson and Neogi, 2004; Felson *et al.*, 2002; Golightly *et al.*, 2007; Sharma and Chang, 2007; Sharma *et al.*, 2001; Teichtahl *et al.*, 2006). Joint specific anatomy may also be a major factor as hinge joints (knee) and ball-and-socket joints (hip) may cope differently with risk factors associated with OA, such as mechanical loading and/or overweight (Reijman *et al.*, 2007). Whilst discussing joint compartment–related differences on OA, one should do so addressing sex compartmental-related differences in cartilage development, as sex may be one explanation for variations in the pattern of knee OA seen in later life (Jones *et al.*, 2000). Sex-specific differences between males and females may therefore be associated with differences in the joint morphology (Cicuttini *et al.*, 1999; Cicuttini *et al.*, 2003; Wluka *et al.*, 2005). Cicuttini and colleagues (1999) showed that on average, males had significantly larger femoral and patella cartilage volumes than females, independent of age, body size and bone size. The authors also acknowledge the need for more insight perspectives in the sex-specific studies regarding cartilage development (Cicuttini *et al.*, 1999). The fact that joints' morphology may have a part to play in the development of degenerative joint lesions, or susceptibility to joint diseases (Cicuttini *et al.*, 1999; Jones *et al.*, 2000; Shepstone *et al.*, 2001), is another issue to be incorporated into bioarchaeological analysis.

Apart from the dynamic within the anatomical compartments of a joint, as exemplified with the shoulder joint, another contributory and relevant factor in the outcome of OA is age. Although age is one of the major variables to be taken into consideration in the analysis of degenerative lesions in the skeletal remains, its assessment in bioarchaeological material is not uncontroversial. Sometimes, it is even unachievable, making many of the sex, occupational and population comparisons if not obsolete, at least debatable. For instance, in general and in this research, women had the highest frequency, probabilities and severity of DBC, OA and MSM. One could therefore conclude that women were engaged in more strenuous activities than men. However, further testing revealed that age biased some of the sex-related changes found. This was demonstrated when logistic regression analysis was applied to DMSM variables, less so in OA analysis. Some of the results of logistic regression showed that sex was not a significant predictor in the outcome of OA and MSM, whilst age was found to be significant in all accounts (see sections: 6.1.2.5; 6.2.6). The statistical analysis also revealed cases where both sex and age had a significant outcome in DMSM, and OA, despite the fact that no statistically significant differences had been found between sexes. This is illustrative of the fact that different statistical tests are to be considered in the analysis of bony changes, and that different results may be achieved depending on the statistical test performed. Once more, this fact emphasises the importance of standardization in the statistical methods of bioarchaeological analysis.

In fact, even the safest assumption that overuse of right side limbs will have a stronger influence on the outcome of DBC, OA or MSM needs further and more detailed testing. The right side development of more frequent and more severe lesions of DBC and MSM, as expected based on the assumption that the majority of the population is dextral (Blackburn and Knüsel, 2006; Holder, 2001) and that these bony changes are related to activity, may not be directly related. However, it would be interesting to further test this supposition performing longitudinal studies between dextral and sinistral (left-handed) individuals engaged in similar and differential activities. MSM results showed a higher variability of ambidextral situations where right and left-hand side enthesis values were significant (section 6.2.1). Maybe these later results are more related to reality, than an overall right side pattern of changes.

In 2007, Elizabeth Weiss and Robert Jurmain described the overall problems of OA in the context of bioarchaeology. In their paper they discuss some issues related to OA analysis, namely its terminology, aetiology and the importance given to mechanical loading. A strong emphasis was placed onto the multifactorial aetiology of OA, and recent research on genetics, anatomy, body mass index and mechanical loading was discussed. Many of the concerns had already been expressed in the past, and more recently by Jurmain and colleagues (1999, 1995; to name but a few). One should add that Jurmain's critical appraisal of OA was conducted alongside that of MOS, and therefore other MOS such as MSM, were also subject to scrutiny (Jurmain, 1999).

Adding to this general perspective of caution in the interpretation of DBC, OA and MSM, one should also focus on the aims of bioarchaeological research, and how to achieve these aims with 100% reliability. Ultimately, if the objective is to compare bioarchaeological data with clinical and epidemiological information, how can this be accomplished?

Given the impossibility of knowing whether bioarchaeologists are reporting real OA frequencies, or if MSM possesses a strong relationship with occupation, perhaps it would be reasonable to refer to the degenerative bony changes simply as they are known:

osteophytes, eburnation, porosity and enthesopaties. Further, the idea that OA is the "most common" condition found in archaeological samples made it a readily identifiable marker. However, comparable to the affirmation that if the pelvic bones are recovered the sexing of the skeleton is a given, the argument that specific changes in the joints are related to OA is a very simplistic one. Neither the sexual diagnosis of human skeletal remains is of mathematical precisions (as discussed in Chapter 2), nor are degenerative changes found in the joints straightforwardly related with OA. With regard to MSM, the overall notion that changes in the entheses are related with activity is also worthy of extensive discussion (as seen in Chapter 3). The core of the discussion being that entheses are heterogeneous, and therefore skeletal sites may behave differently when subjected to similar loadings. Therefore, the analysis of behavioural based changes in the entheses needs to be discussed within a framework wider than occupation and/or activity.

The differences in methods between clinical and bioarchaeological analyses is one of the major handicaps in bioarchaeological analysis, particularly because many bioarchaeological studies aim to compare archaeological populations with data retrieved from a clinical context. If a population comparison is one's aim, at least data from a clinical context will be used to justify, interpret and draw conclusions, as done in this research. Bearing this in mind, bioarchaeology should therefore conduct its research within a multidisciplinary framework, side by side with clinicians and epidemiologists, to develop systematic and pathology related methodologies. The understanding of osseous changes needs to be related to the living, which is only achievable in the realm of medicine. Only then can one try to infer the meaning of the changes in the past population. This type of analysis would eliminate some of the existing bias concerning the aetiology of the degenerative changes - which one should relate with a particular condition, and which one of them should be used as diagnostic criteria in osteological material. Unfortunately, this would not address issues related to the importance of chronological, geographical and genetic variation of bone changes in archaeological populations. In this sense, the analysis of past populations needs to build further bridges. For instance, ancient DNA could potentially provide data on the genetic background of past population, allowing one to trace some of the genetical variation between population, placing this within chronological and geographical context. This data allied with information retrieved from a socio-cultural anthropological context would complement the research. Statistical analysis, on the other hand, could provide the basis upon which a research design could be conceived so that, whilst collecting the data, one could aim to account for as many variables as possible.

In conclusion, the overall assessment of the DBC, OA and MSM showed that the original intended approach to the data would not be representative of the overall degenerative osteological changes observed in the samples. For instance, the use of OA diagnosis criteria excluded a significant number of cases in which severe lesions were present. Furthermore, the nature of the data, either ordinal or dichotomous, would prevent testing some of the original hypotheses of this research, whilst controlling for age, as this is known to be a major confounder variable in the analysis of age-related degenerative bony changes. Consequently, the original strategy of analysis of the data was altered. So that all type and degrees of DBC could be utilized in the present research, a new set of variables was created based on the original data collected. These new variables corresponded to the sum of the DBC by joint, limb and ultimately per individual. Higher values would represent joints, limbs or individuals with more severe DBC. Ultimately, the value analysed per joint, limb or individual would be one of "intensity" of lesion. The overall template of DBC grouping was also used for MSM lesions. That is, entheses were grouped according to the most proximal joint, and then analysed per joint, limb and individual. Left and right sides were analysed separately for all variables, so that bilateral asymmetry could be tested. Detailed schematics of the grouping of the DBC and MSM can be observed in Table 53. With this strategy, one gains an overall perception of the changes. Additionally, because the analyses were progressive, that is, first the joints were analysed, then the limbs, and finally the individual, some individuality related to the anatomy of the joints, limbs and individuals was preserved. The final objective was to relate the overall changes, associated with the joint and limb movement (Table 54), with particular patterns of activities and ultimately discuss gender.

Table 53 – Schematic of the grouping of the original data according to the new variables created.

Individual					
Limb					
	Joint	Bone	Articular surface	Bone	Enthesis / anatomical *loci*
Upper	Shoulder	Clavicle	Acromion	Clavicle	Acromial extremity – *Trapezius muscle*
		Scapula	Acromion	Clavicle	Acromial extremity – *Deltoideus muscle*
		Scapula	Glenoid cavity	Clavicle	Impression for costoclavicular ligament
		Humerus	Humeral head	Clavicle	Corocoid process
				Scapula	Acromion - *Deltoideus muscle*
				Scapula	Acromion – *Trapezius muscle*
				Humerus	Surgical neck
				Humerus	Greater tubercle
				Humerus	Lesser tubercle
				Humerus	Deltoid tuberosity
	Elbow	Humerus	Distal end	Humerus	Lateral epicondyle
		Radius	Proximal end	Humerus	Medial epicondyle
		Ulna	Proximal end	Radius	Radial tuberosity
				Ulna	Olecranon
				Ulna	Ulna tuberosity
	Wrist	Radius	Distal end		
		Ulna	Distal end		
				Radius	Inter-osseous border - *Pronator teres* insertion
Lower	Hip	Coxal	*Acetabulum*	Os coxa	*Ischium* tuberosity
		Femur	Proximal end	Os coxa	Iliac crest
				Femur	Greater trochanter
				Femur	Gluteal tuberosity
	Knee	Femur	Distal end	Femur	Medial supracondylar line
		Tibia	Proximal end	*Patella*	Base of anterior surface
		Patella		Tibia	Anterior tuberosity
				Tibia	Soleal line
				Femur	Linea aspera
	Ankle	Tibia	Distal end	Tibia	Fibular notch
		Fibula	Distal end	Calcaneus	Posterior surface of calcaneus
				Calcaneus	Plantar surface

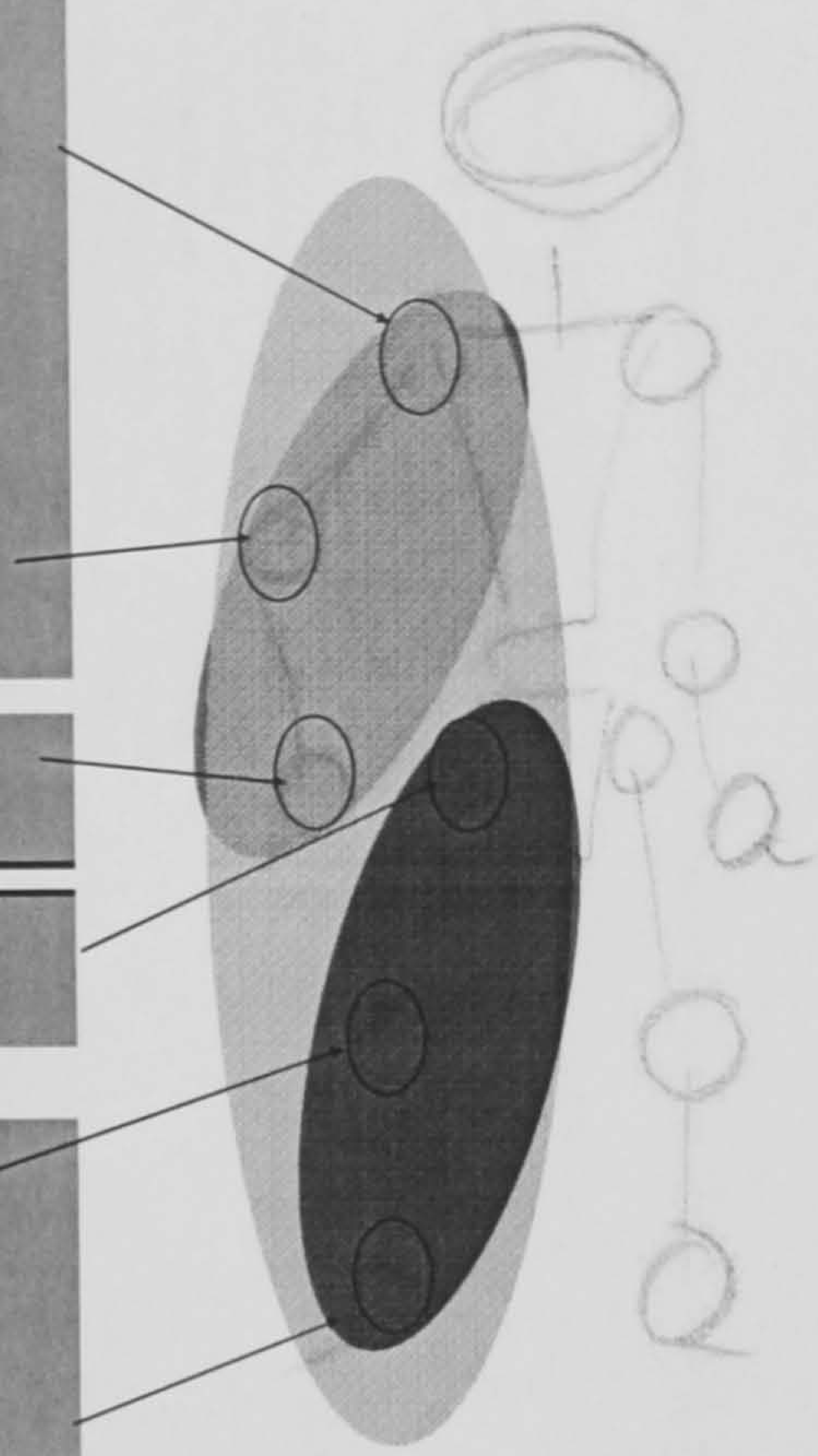

Table 54 – Table of joints, auricular anatomical areas, movements and muscles (adapted from Gray, 2005 (1918); Gunn, 2002).

Joint	Anatomical articular areas	Movements	Muscles	Basic joint movements definition
Shoulder	head of humerus with the glenoid cavity of the scapula	flexion	pectoralis major and anterior fibers of the deltoid	
		extension	posterior fibers of the deltoid and teres major, assisted by the latissimus dorsi	**Gliding Movement**—Giding movement correspond to the surface gliding, or surfaces moving over another without any angular or rotatory movement. It is common to all movable joints, and the only motion permited in some, such as the articulations of the carpus and tarsus. This movement is not confined to plane surfaces, but may exist between any two contiguous surfaces, of whatever form.
		abduction	deltoid	
		adduction	pectoralis major and latissimus dorsi, assisted by the teres major	
		medial rotation	pectoralis major, andterior fibers of the deltoid, teres major and subscapularis	
		larteral rotation	posterior fibers of the deltoid, infraspinatus and teres minor	
	Acromioclavicular	circumduction	combination of all the above	
	acromial end of the clavicle with the medial aspect of the acromion process of the scapula	gliding		
Elbow	throclea articulates with the notch of the ulna	flexion	biceps, brachialis and brachioradialis	**Angular Movement**—Angular movement occurs only between the long bones, and by it the angle between the two bones is increased or diminished. It may take place: (1) forward and backward, constituting flexion and extension; or (2) toward and from the median plane of the body, or, in the case of the fingers or toes, from the middle line of the hand or foot, constituting adduction and abduction. The strictly ginglymoid or hinge-joints admit of flexion and extension only. Abduction and adduction, combined with flexion and extension, are met with in the more movable joints; as in the hip, the shoulder, the wrist, and the carpometacarpal joint of the thumb.
	capitulum articulates with the head of the radius	extension	triceps	
Wrist	distal end of radius with scaphoid and lunate	flexion	flexor carpi radialis and flexor carpi ulnaris	
	articular disc of the inferior radio-ulnar joint with the lunate and triquetral	extension	extensor carpi radialis and extensor carpi ulnaris	
		abduction	flexor and extensor carpi radialis	
	the carpal bones are united by interrosseous ligaments	adduction	flexor and extensor carpi ulnaris	
Hip	head of femur with the *acetabulum*	flexion	iliacus and the psoas assisted by the rectus femoris	
		extension	gluteus maximus assisted by the hamstrings	
		abduction	gluteus medius and the gluteus minimus	
		adduction	adductor	
		medial rotation	anterior parts of the gluteus medius, the gluteus minimus and the tensor fasciae latae	**Circumduction**—Circumduction is that form of motion which takes place between the head of a bone and its articular cavity, when the bone is made to circumscribe a conical space; the base of the cone is described by the distal end of the bone, the apex is in the articular cavity; this kind of motion is best seen in the shoulder and hip-joints.
		lateral rotation	obturador, gemelli and quadriceps femoris	
		circumduction	comnination of all the above	
Knee	femoral condyles with the tibial condyles	flexion	hamstring muscles aided by the gastrocnemius	
	posterior aspect of the *patella* with the patellar articular surface of the femur	extension	quadriceps femoris	**Rotation**—Rotation is a form of movement in which a bone moves around a central axis without undergoing any displacement from this axis; the axis of rotation may lie in a separate bone, as in the case of the pivot formed by the odontoid process of the axis vertebræ around which the atlas turns; or a bone may rotate around its own longitudinal axis, as in the rotation of the humerus at the shoulder-joint; or the axis of rotation may not be quite parallel to the long axis of the bone, as in the movement of the radius on the ulna during pronation and supination of the hand, where it is represented by a line connecting the centre of the head of the radius above with the centre of the head of the ulna below.
		when the knee is flexed there is a minimal degree of:		
		medial rotation	popliteus	
		lateral rotation	biceps femoris	
Ankle	distal end and medial malleolus of the tibia, medial aspect of the lateral malleolus of the fibula, with talus	main:		
		dorsiflexion	anterior tibialis	
		plantarflexion	solues and gastrocnemius	
		accessory movement:		
		abduction	plantar flexion	
		adduction		
		rotation		

Chapter 7: Results II - Analysis of Grouped_Variables, postcranial indices and other markers of occupational markers

The current chapter reports to the results analysis of: the first set of Grouped_Variables; the second set of Groups_Variables; postcranial indices analysis; and finally, trauma, periostitis, Schmorl nodes and spondylolysis. The detailed description of the grouping of DBC and MSM into new variables can be found in the final discussion of the previous chapter (6). The same section of the Chapter refers to the reasons behind the grouping of the DBC and MSM variables. The major aim of this chapter is to introduce the results to be used in the discussion of gender, through the comparative analysis of osteological changes between occupational groups. In the end of each section of results a brief discussion and summary of the major results will be provided.

The first set of Grouped_Variables analysed were:

1. SumDBC – sum of all degenerative lesions analysed by articular surface (porosity, marginal lipping, osteophytes and eburnation) by joint; and SumMSM – sum of muscular stress lesions according to joint. For instance, SumMSM_Shoulder resulted from MSMs observed in scapula, clavicle and proximal extremity of the humerus (as illustrated in the previous chapter).
2. SumDBC_Upper and lower limbs – sum of all degenerative lesions according to limb; and SumMSM_Upper and lower limbs - sum of muscular stress lesions by upper and lower limbs.
3. SumDDB_Total – sum of previous DBC variables per individual skeleton; and SumMSM_Total - sum of previous MSM variables skeleton.

After analysing the SumDBC and SumMSM separately, both types of lesions were combined in a unique variable per joint, limb and individual. These variables were identified as SumDBC_MSM. This allowed for a greater number of individuals to be included in the analysis, permitting more comparisons between subjects. This decision was taken because, although the variables refer to different *loci*, the first being the joints the second the muscular insertion sites, the results showed that the presence and severity of lesions followed a similar pattern. That is, an individual with an affected joint would certainly exhibit MSM changes in the entheses associated with that joint. This was tested using to the Spearman's rank correlation test. SumDBC and SumMSM correlation revealed to be statistical significant in all joints: the highest score was obtained for left shoulder, r =0.669, p<0.001; and the lowest score attained for right ankle, r=0.323, p<0.001 (for details see Table 16, Appendix_Grouped_Variables).

Based on these results, BDC and MSM variables were combined into a new set of variables, which corresponds to the second set of Grouped_Variables explored. They were:

1. SumDBC_MSM – sum of both DBC and MSM variables according to joint:

2. SumDBC_MSM_Total_Upper or Lower – sum of previous variables per limb;

3. Total_Sum – sum of previous variables by side.

The overall analysis of the Grouped_Variables and postcranial indices was as follows: descriptive statistics were presented for each variable, followed by inferential statistical tests to determine differences between sexes and occupational groups. SumDBC and SumMSM results were presented together so that comparisons could be made during the analysis. Because this section refers to the analysis of occupational groups, differences between Collections were not considered,[59] however differences between sexes were. Side differences were preserved in all variables.

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[59] Collections sub-samples were not tested because as demonstrated in the previous Chapter (6) the major differences found between DBC and MSM in LLSC and CISC were significantly related to the age at death of their respective individuals, particularly females in the LLSC, and not with any specific collection trait. Therefore, any inference made in the analysis of DBC and MSM should aim to control for age as a major confounder variable. The influence of sex was minor, with some rare exceptions, and the skeletal collection's provenance could be disregarded as a contributor in DBC and MSM presence.

The remaining MOS, trauma, periostitis, Schmorl's nodes and spondylolysis analysis was concise. Sex and collection sub-samples differences, as well as occupation and age at death associations were tested. These data were used as a complementary to the Grouped_Variables and postcranial indices. They were regarded as satellite lesions, and not as the core lesions of the present research.

7.1 Analysis of Grouped_Variables

7.1.1 Analyses of SumDBC and SumMSM variables

7.1.1.1 Analysis of SumDBC and SumMSM per joint

7.1.1.1.1 SumDBC and sumMSM per joint: summary statistics and bilateral asymmetry

Descriptive statistics of the analysis of the SumDBC and SumMSM variables can be observed in Tables 55 and 56. All the values were positively skewed, indicating that the majority of cases represent lower, to null values of lesions, and that the distribution varied significantly from a normal distribution: these results were confirmed by the Shapiro-Wilk statistic ($p<0.001$) and observed for both left and right side variables. The joints with the higher SumDBC and SumMSM scores were shoulders and hips, and those with the lower scores were ankles and wrists (see Tables 55 and 56 for details).

Table 55 – Descriptive Statistics: SumDBC.

		SumDBC_Left						SumDBC_Right					
		Shoulder	Elbow	Wrist	Hip	Knee	Ankle	Shoulder	Elbow	Wrist	Hip	Knee	Ankle
N	Valid	599	592	583	599	602	602	597	593	580	601	602	598
	Missing	4	11	20	4	1	1	6	10	23	2	1	5
Mean		4.272	2.203	0.798	3.487	3.229	0.525	4.548	2.346	0.909	3.769	3.483	0.562
Std. Deviation		4.904	3.748	1.844	3.050	4.502	0.909	5.134	3.658	2.027	3.417	4.934	0.938
Skewness		1.554	2.976	4.560	1.374	2.211	2.457	1.479	2.699	4.692	1.849	2.308	2.515
Std. Error of Skewness		0.100	0.100	0.101	0.100	0.100	0.100	0.100	0.100	0.101	0.100	0.100	0.100
Minimum		0	0	0	0	0	0	0	0	0	0	0	0
Maximum		33	26	21	19	28	7	31	27	18	22	27	7

Table 56 – Descriptive statistics: SumMSM.

		SumMSM_Left					SumMSM_Right				
		Shoulder	Elbow	Hip	Knee	Ankle	Shoulder	Elbow	Hip	Knee	Ankle
N	Valid	602	599	603	603	599	603	598	603	603	598
	Missing	1	4	0	0	4	0	5	0	0	5
Mean		4.350	1.823	4.249	2.793	2.098	4.473	2.293	4.100	2.781	2.157
Std. Deviation		4.512	2.134	3.592	2.319	2.082	4.191	2.588	2.898	2.370	2.029
Skewness		1.246	1.352	0.428	0.750	0.779	1.136	1.384	0.409	0.875	0.738
Std. Error of Skewness		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Minimum		0	0	0	0	0	0	0	0	0	0
Maximum		21	10	12	12	8	21	12	12	11	8

Following the Wilcoxon signed rank test results, side asymmetry was found in almost all joints of the SumDBC variables, apart from SumDBC_Ankle ($Z=-0.914$, $p=0.363$) and SumDBC_Knee, although its value was marginally significant ($p=0.050$). With regard to SumMSM variables, the contrary was found as only one joint revealed significant asymmetry (Sum_MSM_Elbow, $Z=-6.568$, $p<0.001$) (Table 57). Right side joints were found to be significantly more affected than left side joints for all variables.

Table 57 - Wilcoxon Signed Rank test results: side differences between SumDBC and SumMSM.

		SumDBC						SumMSM				
		Shoulder	Elbow	Wrist	Hip	Knee	Ankle	Shoulder	Elbow	Hip	Knee	Ankle
Z		-2.005	-2.029	-2.196	-2.811	-1.949	-0.914	-1.471	-6.568	-1.659	-0.487	-0.829
Monte Carlo Sig. (2-tailed)		0.044	0.042	0.027	0.004	0.050	0.363	0.144	<0.001	0.099	0.63	0.417
99% Confidence Interval	Lower Bound	0.038	0.037	0.023	0.002	0.044	0.351	0.135	<0.001	0.092	0.617	0.404
	Upper Bound	0.049	0.047	0.031	0.006	0.056	0.376	0.153	<0.001	0.107	0.642	0.429

7.1.1.1.2 SumDBC and sumMSM per joint: analysis by sex of the individuals

Statistically significant differences between men and women were found in the right elbow ($p=0.042$) and knees ($p<0.001$) of SumDBC, and on the hips and ankles ($p<0.05$) of SumMSM (Tables 58 and 59). In all cases women had higher mean scores than men (detailed descriptive statistics can be consulted in the Appendix_Grouped_Variables: Table 17 and 18). When sex sub-samples were tested for bilateral asymmetry, significant differences were found for SumDBC and SumMSM female hips ($p<0.05$), and for SumMSM female elbow ($p<0.001$). In males side differences were found for the shoulder and ankle SumDBC ($p<0.005$), and for SumMSM in the elbow ($p<0.001$) (Tables 60 and 61). Apart from female SumMSM of the hips, where left side dominance was found, all cases had right side dominance.

Table 58 – Mann_Whitney statistical test results: sex differences SumDBC.

SumDBC		Left						Right					
		Shoulder	Elbow	Wrist	Hip	Knee	Ankle	Shoulder	Elbow	Wrist	Hip	Knee	Ankle
U		41779.5	40318.5	41872	43549	37602.5	43921	44453	39889	41804.5	45017	36481	41431
Z		-1.468	-1.761	-0.364	-0.620	-3.698	-0.771	-0.047	-2.032	-0.140	-0.063	-4.224	-1.805
Monte Carlo Sig. (2-tailed)		0.142	0.077	0.717	0.531	<0.001	0.441	0.965	0.042	0.891	0.948	<0.001	0.071
99% Confidence Interval	Lower Bound	0.133	0.071	0.705	0.518	<0.001	0.428	0.960	0.037	0.883	0.942	<0.001	0.064
	Upper Bound	0.151	0.084	0.729	0.544	0.001	0.454	0.970	0.047	0.899	0.954	<0.001	0.077

Table 59 - Mann_Whitney statistical test results: sex differences SumMSM.

SumMSM		Left					Right				
		Shoulder	Elbow	Hip	Knee	Ankle	Shoulder	Elbow	Hip	Knee	Ankle
U		44973.5	44191	37799.5	42221	39816.5	43700.5	41747.5	39712	43193.5	39116
Z		-0.154	-0.321	-3.605	-1.526	-2.428	-0.823	-1.430	-2.698	-1.066	-2.694
Monte Carlo Sig. (2-tailed)		0.880	0.742	<0.001	0.130	0.014	0.407	0.153	0.008	0.289	0.007
99% Confidence Interval	Lower Bound	0.872	0.731	<0.001	0.121	0.011	0.395	0.144	0.005	0.277	0.005
	Upper Bound	0.888	0.753	0.001	0.138	0.017	0.420	0.162	0.010	0.300	0.009

Table 60 - Wilcoxon Signed Rank test results: side differences between SumDBC per sex sub-samples.

		SumDBC_Female						SumDBC_Male					
		Shoulder	Elbow	Wrist	Hip	Knee	Ankle	Shoulde	Elbow	Wrist	Hip	Knee	Ankle
Z		-0.333	-1.204	-1.343	-2.21	-1.379	-1.828	-3.275	-1.672	-1.769	-1.773	-1.418	-2.847
Monte Carlo Sig. (2-tailed)		0.747	0.236	0.179	0.030	0.168	0.066	0.001	0.097	0.077	0.075	0.160	0.004
99% Confidence Interval	Lower Bound	0.736	0.225	0.169	0.026	0.159	0.060	<0.001	0.089	0.070	0.068	0.150	0.002
	Upper Bound	0.758	0.247	0.189	0.034	0.178	0.073	0.002	0.104	0.084	0.082	0.169	0.005

Table 61 - Wilcoxon Signed Rank test results: side differences between SumMSM per sex sub-samples.

		SumMSM_Female					SumMSM_Male				
		Shoulder	Elbow	Hip	Knee	Ankle	Shoulder	Elbow	Hip	Knee	Ankle
Z		-0.300	-5.396	-3.005	-0.091	-0.940	-1.602	-3.807	-0.706	-0.759	-0.219
Monte Carlo Sig. (2-tailed)		0.768	<0.001	0.003	0.923	0.347	0.112	<0.001	0.480	0.448	0.832
99% Confidence Interval	Lower Bound	0.757	<0.001	0.002	0.916	0.335	0.103	<0.001	0.467	0.435	0.822
	Upper Bound	0.779	<0.001	0.005	0.930	0.359	0.120	<0.001	0.492	0.461	0.841

Additional testing was done to ensure that the differences found between sexes were well-founded and not due to the effects of age, since as demonstrated in previous analyses of the separated DBC and MSM variables, increasing age had a considerable effect in the development of these degenerative lesions in the skeleton. Hierarchical regression[60] statistics showed that sex was not a significant predictor in the outcome of any of the Sum variables ($p>0.05$), whilst age was ($p<0.001$). An exception was found for SumDBC in the knees, were both sex and age revealed to significant predictors in the outcome of degenerative lesions ($p\leq0.009$) (see Table 20 and 21 in Appendix_Grouped_Variables).Therefore, Mann-Whitney test results of sex differences expressed not only differences between the sex of individuals, but also the fact that women were older than men, and consequently more predisposed to exhibit these degenerative lesions.

[60] See description in the Appendix_Grouped_Variables: hierarchical regression results, section 1.1.1.3.

7.1.1.1.3 SumDBC and sumMSM per joint: analysis according to occupational group

Throughout the research it became evident that any analysis performed in this sample would have to consider the effects of age. The Kruskal-Wallis test confirmed the presence of significant differences between age at death by occupational group[61] ($H=35.120$, $p<0.001$). The pairwise comparison between groups distinguished two homogenous subgroups:

1	2
Army/Navy	Government administration/Services
Farmers/Servants	Housewives
Skilled workers/Artisans	
Unskilled workers	
Commerce/Transport	

The first sub-group contained the occupational categories with the middle aged to younger individuals of the sample, and the second sub-group comprised the older individuals. The major differences were found between Army/Navy and the Government administration/Services and Housewives categories, as exemplified in Figure 41. Detailed descriptive statistics per groups are presented in Table 62.

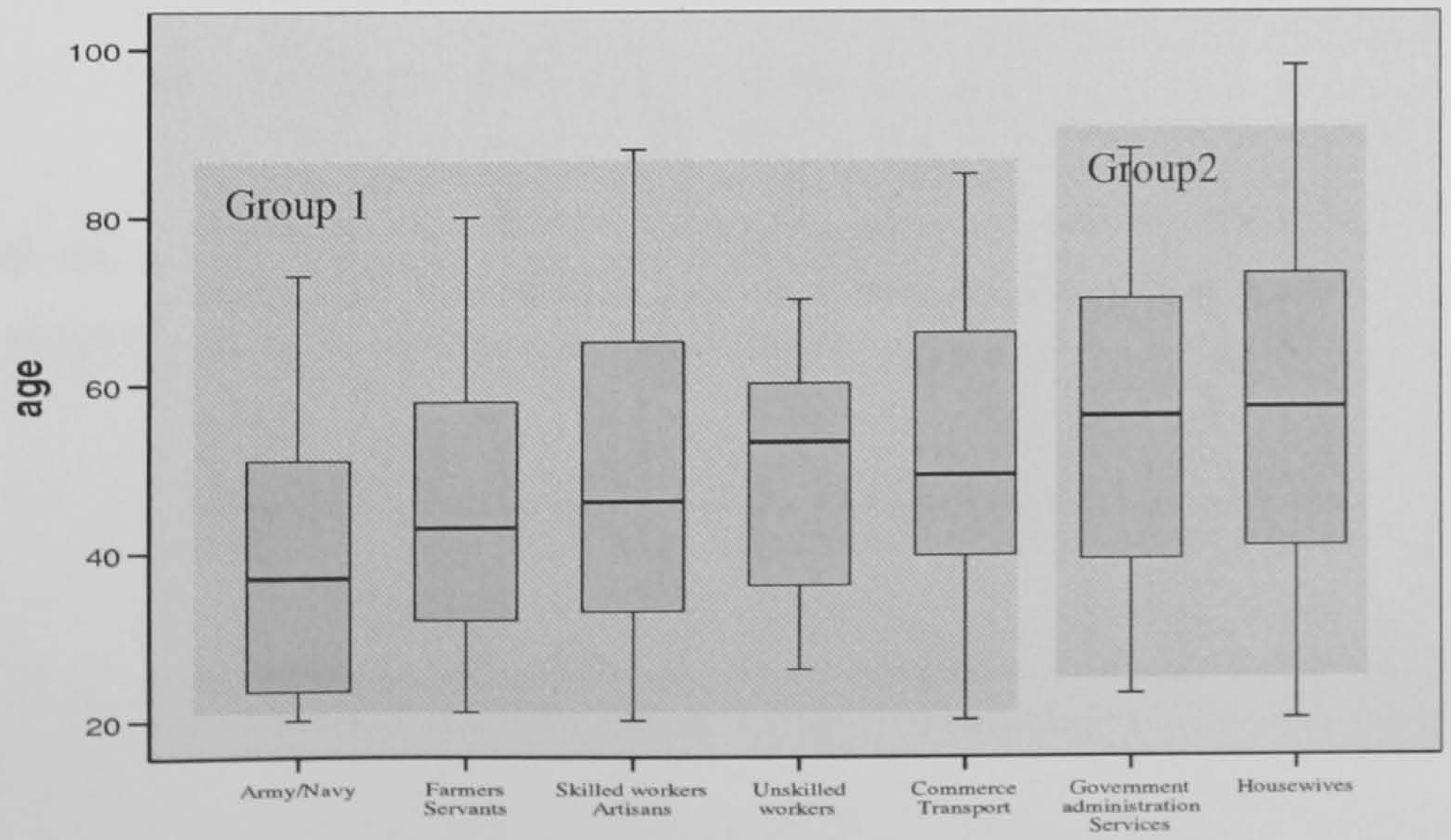


Figure 41 – Boxplot of the mean age at death values of individuals of the total sample according to occupational group classification. The mean age is represented by the line in the box's centre.

[61] Detailed description of the Occupational Groups, as well as occupations and criteria used for their composition can be found in the Material Chapter (5).

Table 62 – Descriptive statistic of age at death according to occupational groups.

Occupational Groups	N	Mean	Std. Deviation	Minimum	Maximum
Government administration/Services	52	55.6	17.73	23	88
Commerce/Transport	85	51.26	17.5	20	85
Skilled workers/Artisans	102	48.76	18.32	20	88
Farmers/Servants	28	46.54	17.93	21	80
Unskilled workers	37	49.22	13.32	26	70
Army/Navy	23	38.35	15.89	20	73
Housewives	276	56.74	19.59	20	98
Total	603	52.88	18.89	20	98

The Kruskal-Wallis test revealed a statistically significant difference between occupational groups and the mean values of SumDBC and SumMSM (for details on these statistics see Table 26 to 28 in Appendix_Grouped_Variables). However, due to the already proven association between age and DBC, as well as MSM, another test was performed so that the importance of age could be accounted for. The test performed was analysis of covariance (ANCOVA), with occupational groups as a fixed factor and age as a covariante. The results confirmed that age, as a covariant, had a significant impact in the development of degenerative lesions ($p<0.001$), while the importance of the occupational groups was generally non-significant (Table 63 and 64). Hence, the differences in mean values of *Sum* variables in occupational groups reflected the ages of the individuals that compose the groups and not occupational effects. Nevertheless, occupational group significance was found for some variables, allowing the assumption that, maybe in these particular cases, activity played a role. The cases were listed below:

– SumDBC – right shoulder, hips and right ankle;

– SumMSM – shoulders, knees and left elbow.

Table 63 – ANCOVA test results: SumDBC.

SumDJD_Left					SumDJD_Right				
		df	F-value	Sig.			df	F-value	Sig.
Shoulder	Age	(1,591)	376.705	<0.001	Shoulder	Age	(1,589)	376.632	<0.001
	Occupation	(6,591)	0.495	0.812		Occupation	(6,589)	2.469	0.023
Elbow	Age	(1,584)	134.157	<0.001	Elbow	Age	(1,585)	193.541	<0.001
	Occupation	(6,584)	0.795	0.574		Occupation	(6,585	0.88	0.509
Wrist	Age	(1,575)	84.982	<0.001	Wrist	Age	(1,572)	97.023	<0.001
	Occupation	(6,575)	1.349	0.233		Occupation	(6,572)	1.550	0.16
Hip	Age	(1,591)	372.693	<0.001	Hip*	Age	(1,593)	543.559	<0.001
	Occupation	(6,591)	3.354	0.003		Occupation	(6,593)	3.375	0.003
Knee	Age	(1,594)	235.931	<0.001	Knee	Age	(1,594)	214.061	<0.001
	Occupation	(6,594)	1.305	0.253		Occupation	(6,594)	1.782	0.1
Ankle	Age	(1,594)	95.664	<0.001	Ankle	Age	(1,590)	70.560	<0.001
	Occupation	(6,594)	1.179	0.316		Occupation	(6,590)	2.957	0.007

*- Rawdata results.

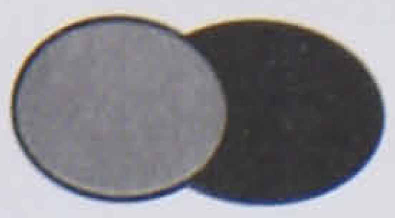
Table 64 - ANCOVA test results: SumMSM.

SumMSM_Left					SumMSM_Right				
		df	F-value	Sig.			df	F-value	Sig.
Shoulder	Age	(1,594)	360.839	<0.001	Shoulder	Age	(1,595)	341.203	<0.001
	Occupation	(6,594)	2.558	0.019		Occupation	(6,595)	4.364	<0.001
Elbow*	Age	(1,591)	386.547	<0.001	Elbow	Age	(1,590)	360.281	<0.001
	Occupation	(6,591)	3.077	0.006		Occupation	(6,590)	1.135	0.340
Hip	Age	(1,595)	564.664	<0.001	Hip*	Age	(1,595)	376.813	<0.001
	Occupation	(6,595)	1.225	0.291		Occupation	(6,595)	1.418	0.205
Knee	Age	(1,595)	195.256	<0.001	Knee	Age	(1,595)	164.564	<0.001
	Occupation	(6,595)	4.536	<0.001		Occupation	(6,595)	4.065	0.001
Ankle	Age	(1,591)	99.526	<0.001	Ankle	Age	(1,591)	119.713	<0.001
	Occupation	(6,591)	0.620	0.714		Occupation	(6,591)	0.669	0.674

*- Rawdata results.

To determine which occupational groups differed regarding SumDBC and SumMSM, post hoc tests using the estimated mean results of the ANCOVA test were undertaken. The mean values referred to the mean values of SumDBC and SumMSM obtained per occupational group.

To understand the following figures, which show the relationship of the mean values from SumDBC and SumMSM according to occupational groups, consider the following example and apply this interpretative template to the respective figures:



- each circle corresponds to an occupational group;
- the overlap of circles identifies a statistically significant relation between them;
- the circle on top identifies the group with the higher mean value (in this case the grey circle), and underneath represents the occupational group with the lower mean value (in this case the black circle).

The first sets of significant results correspond to the SumDBC variables. As already stated, significant statistical differences between occupational groups were found in four articulations (Figure 42):

- SumDBC_Right_Shoulder - unskilled workers had higher mean values than individuals working in administration and services, skilled workers and artisans, and housewives; housewives had significantly lower values than individuals working in occupations related with commerce and transport:

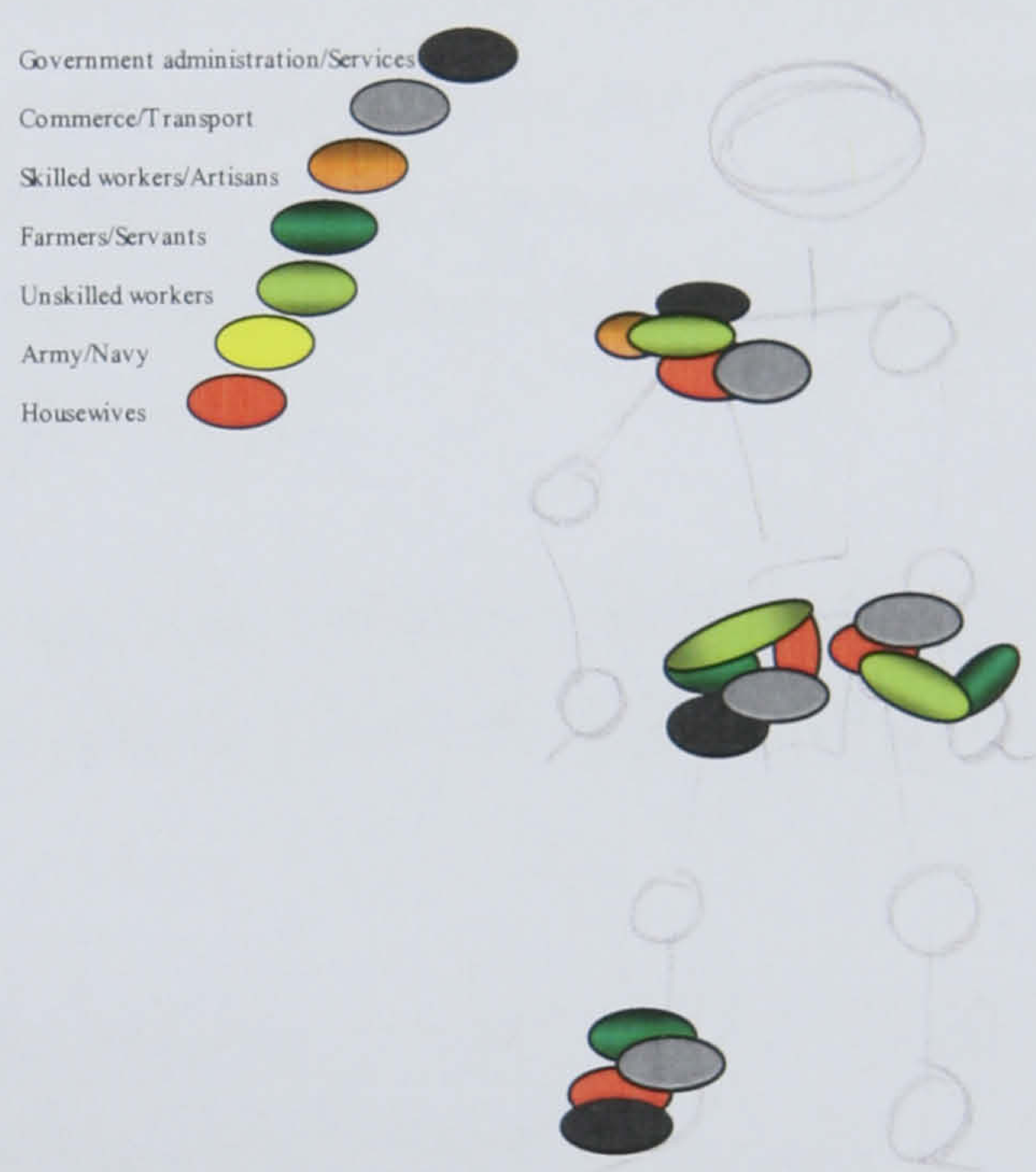


Figure 42 - SumDBC results of pairwise comparisons.

- SumDBC_Left_Hip - individuals working in commerce and transport had significantly higher values than individuals working in administrative services, farmers and servants, and housewives; farmers and servants had significant lower mean values than individuals working in transport and commerce and unskilled activities; unskilled workers had higher values than farmers and servants, and housewives; and finally, housewives had significantly lower value than commerce and transport employees as well as unskilled workers:

- SumDBC_Right_Hip – individuals working in activities related with commerce and transport had significantly higher mean values than housewives; farmers and servants had lower values than unskilled workers; unskilled workers had higher values than farmers and servants, and housewives:
- SumDBC_Right_Ankle – housewives had a significant lower mean value than people working in administration service, and commerce and transport; individuals employed in the last activities had higher values than housewives and farmers and servants.

The overall pattern of significant differences of the Sum_DBC variables illustrated that individuals with activities related to commerce and transports, as well as unskilled labour, possessed the highest estimated mean of lesions when compared to the other occupational groups. On the other hand, the occupational group represented by housewives, farmers and servants had the lowest estimated mean values when compared to the other groups. In all, the significant differences found rotated between these groups.

Significant differences between occupational groups in the SumMSM variables were more complex than those observed in the SumDBC, particularly for the right shoulder and knees. The results found were as follows (Figure 43):

- SumMSM_Left_Shoulder – individuals working as farmers and servants significantly differ from the other occupational groups as they had the lowest mean score;
- SumMSM_Right_Shoulder – in all, significant differences were found between almost all occupational groups, i.e., almost all differ between themselves; individuals working as skilled workers and artisans, unskilled workers, and the armed forces had higher mean scores than people working in administration and services, farming and waitressing, and housewives, all these exhibited lower mean values:
- SumMSM_Left_Elbow – skilled and unskilled workers and artisans exhibited higher mean values than housewives, famers and servants:

- SumMSM_Left_Knee – farmers and servants, and housewives had a significantly lower mean value than almost all the other occupational groups, whilst individuals working in the armed forces, administration and services, and commerce and transport possessed higher mean values of lesions:
- SumMSM_Right_Knee – working in administrative services, commerce, transport and skilled crafts had significantly higher mean value than farmers, servants and housewives.

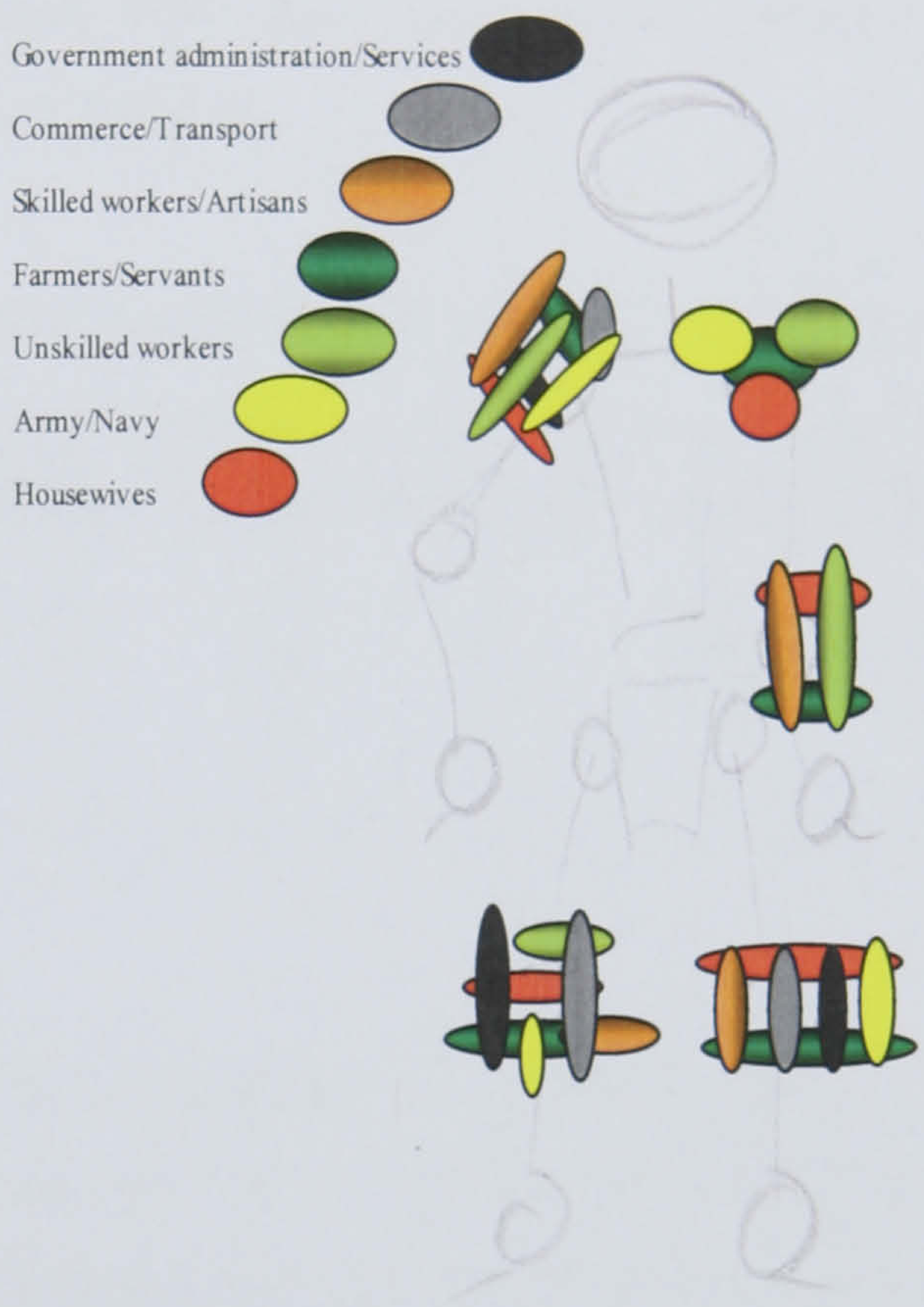


Figure 43 -SumMSM results of pairwise comparisons

Lesions found in the right side joints presented the most complex set of results, that is, a higher number of occupational groups exhibited significant differences between one another. Mean values for left side joints displayed what could be described as a pattern, as only a few number of occupations, specifically those of farmers and servants, and housewives, differed significantly from the rest.

7.1.1.2 Analysis of SumDBC and SumMSM per limbs

7.1.1.2.1 SumDBC and SumMSM per limb: summary statistics and bilateral asymmetry

SumDBC and SumMSM upper and lower limb variables were positively skewed, and had a non-normal distribution as proved by the Shapiro-Wilk statistics ($p<0.001$). Detailed descriptive statistics of the variables are exhibited in Tables 65.

Table 65 – Descriptive Statistics: SumDBC_Upper and lower, and SumMSM_Upper and lower left and right limbs.

		SumDBC				SumMSM			
		Upper_left	Upper_right	Lower_left	Lower_right	Upper_left	Upper_right	Lower_left	Lower_right
N	Valid	602	602	603	603	603	603	603	603
	Missing	1	1	0	0	0	0	0	0
Mean		7.189	7.696	7.212	7.791	7.189	7.804	9.977	9.773
Std. Deviation		8.273	8.759	7.013	7.600	6.868	6.982	7.286	6.554
Skewness		1.574	1.777	1.468	1.461	1.091	1.016	0.493	0.558
Std. Error of Skewness		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Minimum		0	0	0	0	0	0	0	0
Maximum		49	69	40	40	32	35	30	31

Bilateral asymmetry was only absent in the lower limb SumMSM ($Z=-1.262$, $p=0.209$). The remaining variables expressed a right side dominance that was statistically significant (Table 66). When bilateral asymmetry was analysed per sex sub-sample statistical significant differences were found in both upper and lower SumDBC and upper SumMSM ($p\leq0.012$) of the male sub-sample. Statistical significance in the female sub-sample was absent in the SumDBC variables, but present in the SumMSM_Upper limb ($p=<0.001$) and was found to be almost statistically marginal in the SumMSM_Lower limb ($p=0.046$) (Table 67).

Table 66 - Wilcoxon Signed Rank test results: side differences between SumDBC and SumMSM, in total sample, per upper and lower limbs.

		SumDBC		SumMSM	
		Upper	Lower	Upper	Lower
Z		-2.653	-2.985	-4.728	-1.262
Monte Carlo Sig. (2-tailed)		0.009	0.004	<0.001	0.209
99% Confidence	Lower Bound	0.006	0.002	<0.001	0.198
Interval	Upper Bound	0.011	0.006	<0.001	0.219

Table 67 - Wilcoxon Signed Rank test results: side differences between SumMSM in total sample and per sexaul sub-samples.

		SumDBC				SumMSM			
		Female Sample		Male Sample		Female Sample		Male Sample	
		Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Z		-0.178	-1.782	-3.596	-2.467	-2.884	-1.990	-3.771	-0.243
Monte Carlo Sig. (2-tailed)		0.861	0.076	<0.001	0.012	<0.001	0.046	<0.001	0.806
99% Confidence	Lower Bound	0.852	0.069	<0.001	0.010	0.001	0.041	<0.001	0.796
Interval	Upper Bound	0.869	0.083	0.001	0.015	0.004	0.052	0.000	0.816

7.1.1.2.2 SumDBC and SumMSM per limb: analysis according to sex of the individuals

In general females exhibited higher mean values than men, for both SumDBC and SumMSM limb variables (see Table 29: Appendix_Grouped_Variables). Statistically significant differences were only found in SumDBC_lower left limbs (p=0.019). Females exhibited the higher mean rank value score. However, a marginal statistical significance was found for the variables SumDBC_Lower_Right (p=0.061) and SumMSM_Lower_Left (0.057), again women scored higher than men (Table 68).

Table 68 – Mann_Whitney statistical test results: sex differences in SumDBC and SumMSM limbs.

		SumDBC				SumMSM			
		Upper Limb		Lower Limb		Upper Limb		Lower Limb	
		Left	Right	Left	Right	Left	Right	Left	Right
U		41830.000	44324.000	40453.500	41404.000	45139.5	44392.5	41367.5	42632.5
Z		-1.637	-0.460	-2.342	-1.896	-0.146	-0.496	-1.911	-1.319
Monte Carlo Sig. (2-tailed)		0.103	0.650	0.019	0.061	0.878	0.619	0.057	0.189
99% Confidence Interval	Lower Bound	0.096	0.638	0.015	0.055	0.870	0.607	0.051	0.179
	Upper Bound	0.111	0.662	0.022	0.067	0.886	0.632	0.063	0.199

7.1.1.2.3 SumDBC and SumMSM per limb: analysis according to age at death of the individuals

The hierarchical regression tests proved, once more, that age at death was a significant predictor in the development of degenerative lesions ($p<0.001$), whilst sex was not ($p>0.05$). Therefore, one must conclude that the sex differences found in the SumDBC and SumMSM limb variables (see Table 68) resulted from the bias perpetuated by the high frequency of older women, when compared to men (see Tables 30 and 31 in Appendix_Grouped_Variables).

7.1.1.2.4 SumDBC and SumMSM per limb: analysis according to occupational groups

According to the Kruskal-Wallis test statistically significant differences were found between occupational groups for the SumDBC variables, although the value for the upper right limb was only marginal ($p=0.053$). In the case of SumMSM, non-significant values were found for the upper right limb ($p=0.105$), and the lower right limb values were, again, only marginal ($p=0.056$) (see Table 32 in Appendix_ Grouped_Variables). The relationship between occupational groups and the SumDBC and SumMSM limb variables were further tested using the ANCOVA test, so that age at death of the individuals could be accounted for.

The test results confirmed that age, as a covariant, contributed significantly to the development of degenerative lesions (p<0.001) in both upper and lower limbs (SumDBC variables), while the importance of the occupational groups was non significant. Detailed results can be consulted in Table 69. A marginal significance was obtained in the SumDBC_Upper_Right variables (p=0.066), in which occupation could have some bearing on the value of lesions observed. In this particular case, the major differences between occupational groups focus between the unskilled workers group, with a high mean value, and the remaining groups.

Table 69 – ANCOVA test results: SumDBC_Upper and lower limbs.

SumDBC Left		df	F-value	Sig.	SumDBC Right		df	F-value	Sig.
Upper	Age	(1,594)	411.252	<0.001	Upper	Age	(1,594)	443.736	<0.001
	Occupation	(6,594)	0.383	0.890		Occupation	(6,594)	1.986	0.066
Lower	Age	(1,595)	450.488	<0.001	Lower	Age	(1,595)	419.868	<0.001
	Occupation	(6,595)	0.654	0.687		Occupation	(6,595)	0.803	0.568

The analysis of covariance of the SumMSM_Upper limbs revealed that both age and occupational groups had a statistical contribution in the outcome of the lesion; whilst in the lower limb such significance was only achieved for age (Table 70).

Table 70 - ANCOVA test results: SumMSM_Upper and lower limbs.

SumMSM Left		df	F-value	Sig.	SumMSM Right		df	F-value	Sig.
Upper	Age	(1,595)	470.937	<0.001	Upper	Age	(1,595)	501.316	<0.001
	Occupation	(6,595)	3.519	0.002		Occupation	(6,595)	4.594	<0.001
Lower	Age	(1,595)	496.029	<0.001	Lower	Age	(1,595)	398.041	<0.001
	Occupation	(6,595)	1.356	0.231		Occupation	(6,595)	1.494	0.178

Post hoc tests, using the estimated means results of the ANCOVA, permitted the identification of the occupational groups which statistically differed between one another. The results found were as follows (Figure 44):

- SumMSM_Upper_Left – The mean value of lesions observed in the occupational group composed of farmers and servants was statistically lower than the one found in the other groups, with the exception of the Housewives group. Although statistically significant differences were only shown between this group and skilled workers and artisans, in four other comparisons the significance level was marginal: commerce and transport (p=0.062), farmers and servants (p=0.064), unskilled workers (p=0.091) and army and navy (p=0.055).

- SumMSM_Upper_Right – major differences were found to alternate between two group sets: one composed by those exhibiting the lower mean values (governmental administration and services, farmers and servants and housewives); and those with the higher mean values (skilled workers and artisans, unskilled workers, and navy and army employees); commerce and transport groups were found isolated and only significantly differing from the farmers and servants group.

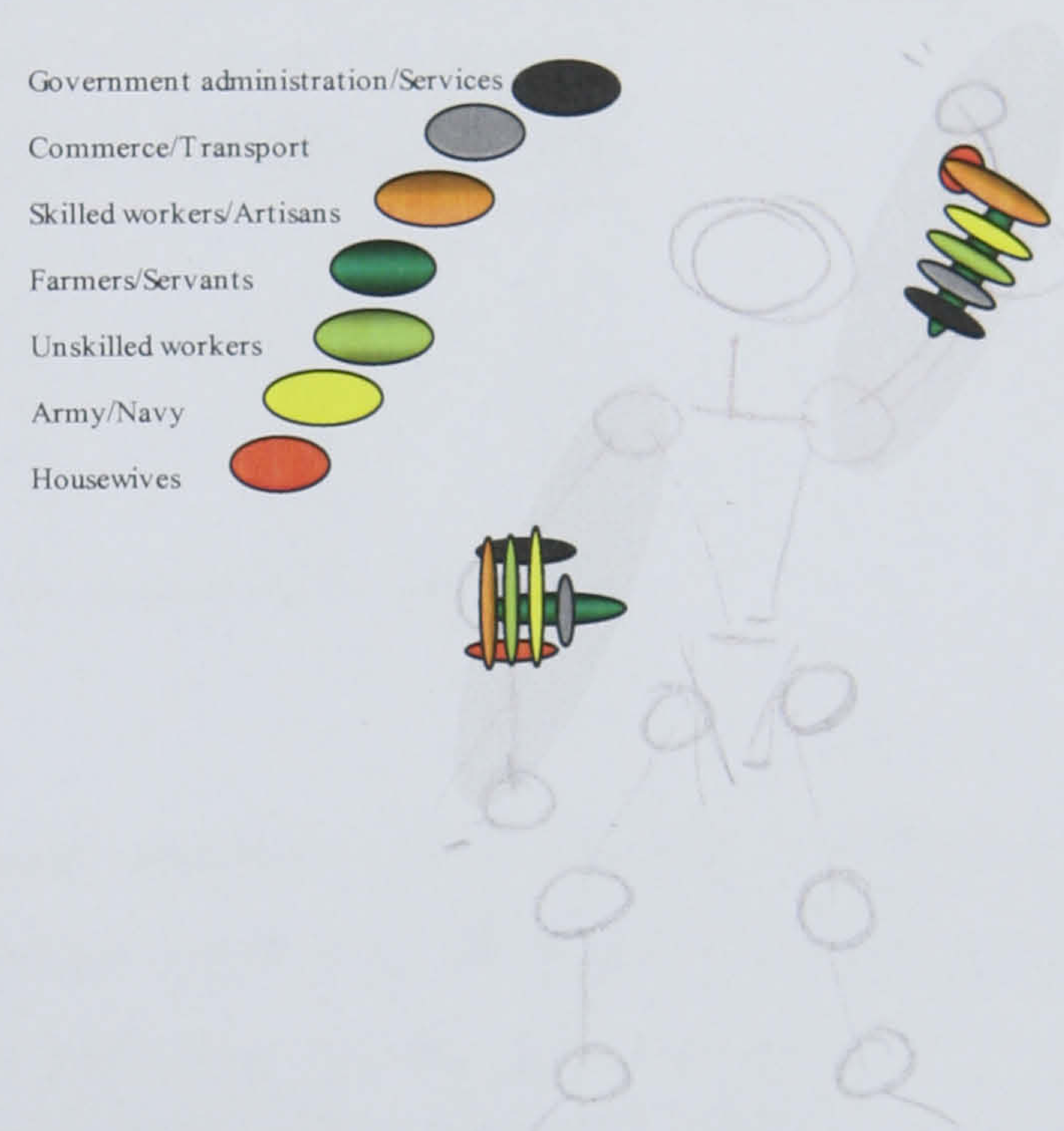


Figure 44 – SumMSM_Upper_Left and right limb results of pairwise comparisons.

In conclusion, SumDBC and SumMSM results showed that when these variables were grouped per limb, occupational group differences were limited to SumMSM, particularly to the upper limb; the differences focused on farmers and servants group having a statistically significant lower mean value of lesions, when compared to the remaining occupations. The housewives groups, as well as government administration and services, revealed to be of occasional significance.

7.1.1.3 Analyses of SumDBC and SumMSM variables per individuals

7.1.1.3.1 SumDBC_Total and SumMSM_Total: summary statistics and bilateral asymmetry

SumDBC_Total and SumMSM_Total variables were positively skewed, possessing a non-normal distribution as proved by the Shapiro-Wilk statistic ($p<0.001$), detailed descriptive statistics are presented in Table 71.

Table 71 – Descriptive Statistics: SumDBC_Total and SumMSM_Total for both left and right side.

		SumDBC		SumMSM	
		Total_left	Total_right	Total_left	Total_right
N	Valid	603	603	603	603
	Missing	0	0	0	0
Mean		14.390	15.474	17.166	17.577
Std. Deviation		13.907	14.686	13.160	12.410
Skewness		1.273	1.246	0.658	0.660
Std. Error of Skewness		0.100	0.100	0.100	0.100
Minimum		0	0	0	0
Maximum		81	91	58	63

When the total sample was tested for bilateral asymmetry a clear right side dominance was found for SumDBC and SumMSM variables (Table 72). When sex sub-samples were analysed, bilateral significant differences were only for the male sub-sample, in both SumDBC and SumMSM variables ($p\leq0.001$). Right side variables had higher scores than left side ones. Female sub-sample exhibited no statistical significant bilateral asymmetry ($p=0.294$ and $p=0.436$ respectively) (Table 72).

Table 72 - Wilcoxon Signed Rank test results: side differences tested in SumDBC_Total and SumMSM_Total varibles. The results include total sample and sex sub-samples data.

		SumDBC_Total			SumMSM_Total		
		Total	Female	Male	Total	Female	Male
Z		-3.601	-1.050	-4.095	-2.807	-0.790	-3.116
Monte Carlo Sig. (2-tailed)		<0.001	0.294	<0.001	0.005	0.436	0.001
99% Confidence Interval	Lower Bound	<0.001	0.282	<0.001	0.003	0.423	<0.001
	Upper Bound	<0.001	0.306	<0.001	0.007	0.448	0.002

7.1.1.3.2 SumDBC_Total and SumMSM_Total: analysis according to sex of the individuals

The only total sum variable in which a statistical significant difference was found between sexes was in the SumDBC_Total_left ($p=0.032$), with females having a higher mean value (Table 73). A hierarchical regression was performed to clarify whether the significant difference found between sexes was being biased by the older age of women in the sample. The results proved that, when sex and age were entered as predictors in the outcome of SumDBC_Total_left sex was not a significant variable ($p=0.204$) but age was ($p<0.001$) (see Table 35 in Appendix_Grouped_Variables). Consequently, one may conclude that the male and female difference was found to be age-related, and not necessarily sex-related.

Table 73 – Mann_Whitney statistical test results: sex differences in SumDBC_Total and SumMSM_Total variables.

		SumDBC_Total		SumMSM_Total	
		Left	**Right**	**Left**	**Right**
U		40959.5	42540.5	43329.5	44373.5
Z		-2.101	-1.361	-0.992	-0.503
Monte Carlo Sig. (2-tailed)		0.032	0.178	0.327	0.620
99% Confidence Interval	**Lower Bound**	0.027	0.168	0.315	0.608
	Upper Bound	0.037	0.188	0.339	0.633

7.1.1.3.3 SumDBC_Total and SumMSM_Total: analysis according to occupational groups.

According to the Kruskal-Wallis test, statistically significant differences per occupational group were found for left and right SumDBC_Total variables, and SumMSM_Total left variable ($p<0.05$). Statistical significance was not achieved in the SumMSM_Total right variable ($p=0.110$) (see Appendix_Grouped_Variables for detailed results: Tables 36 and 37).

ANCOVA test results showed when the raw data of SumDBC_Total variables (left and right), was analysed occupational groups bear no significance in the dependent variable ($p>0.05$). However, if the ranked data[62] was to be taken into consideration, statistical significance was found between occupational groups and the outcome of the dependent variable (SumDBC_Total, right side; $p=0.006$). Both age and occupational groups were significant for SumMSM_Total variables ($p=0.016$ and $p=0.005$, left and right side respectively) (Table 74).

Table 74 – ANCOVA test results: SumDBC_Total and SumMSM_Total left and right variables.

SumDBC_Total					SumMSM_Total				
		df	F-value	Sig.			df	F-value	Sig.
Left	Age	(1,595)	616.072	<0.001	Left	Age	(1,595)	642.878	<0.001
	Occupation	(6,595)	0.405	0.876		Occupation	(6,595)	2.631	0.016
Right*	Age	(1,595)	1060.189	<0.001	Right	Age	(1,595)	620.580	<0.001
	Occupation	(6,595)	3.081	0.006		Occupation	(6,595)	3.120	0.005

*Rank data results.

Occupational group differences were analysed using post hoc pairwise comparison, utilizing the estimated means results of the ANCOVA. The results found, concerning the SumDBC_Total_Right variable illustrated that the major difference were found between individuals grouped in commerce/transport and unskilled workers, which significantly differ from the other groups, having the higher mean values of lesions. The remaining

[62] As discussed in the methods Chapter (4: section 4.2), a Rank Transformation of the variables was performed, so that parametric tests could be used. When a statistical significance was obtained for both raw and ranked data, preference was given to these later ones, based on the assumption that the violation of normality had a minor influence in the outcome of the test. When the test results differed, rank data results were presented, since in these cases the violation of normality appeared to have a bigger impact on the data. Such is the current case: SumDBC_Total_Right.

occupational groups had lower mean scores. The only single interaction was found between government administration and services, and unskilled workers: again the later group had a higher value (Figure 45).

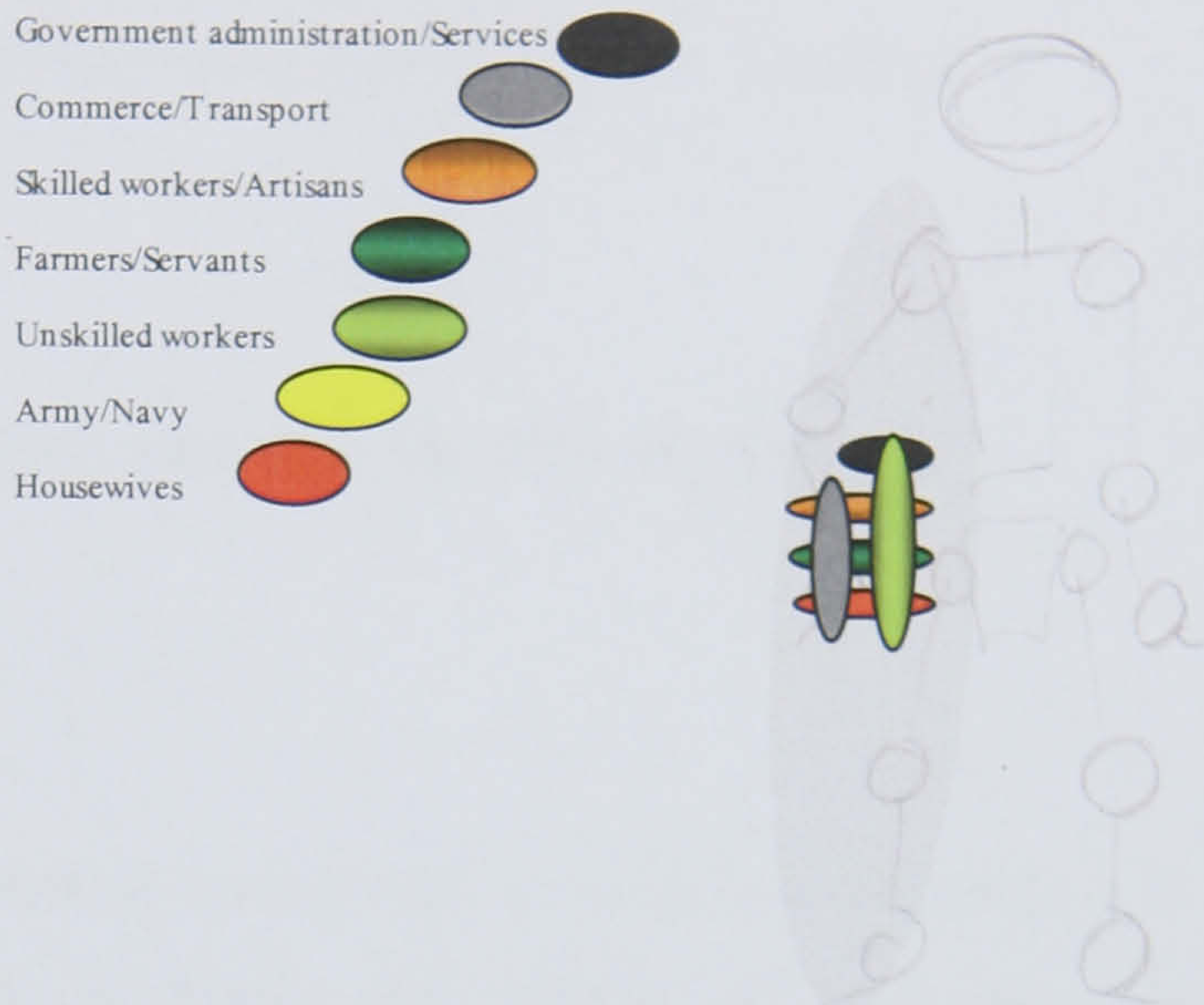


Figure 45 – SumDBC_Total_Right results of pairwise comparisons.

The results of the SumMSM_Total showed more straightforward left side differences, than right side. In the left side, individuals grouped as farmers/servants were categorically different from the rest of the groups, only sharing with the housewives group a lower score of lesion (SumMSM_Total_Left); on the right side, SumMSM_Total farmers/servants and housewives continue to significantly differ from the remaining groups, but other individual statistically significant relationships were found, such as the one between unskilled workers and farmers/servants (Figure 46).

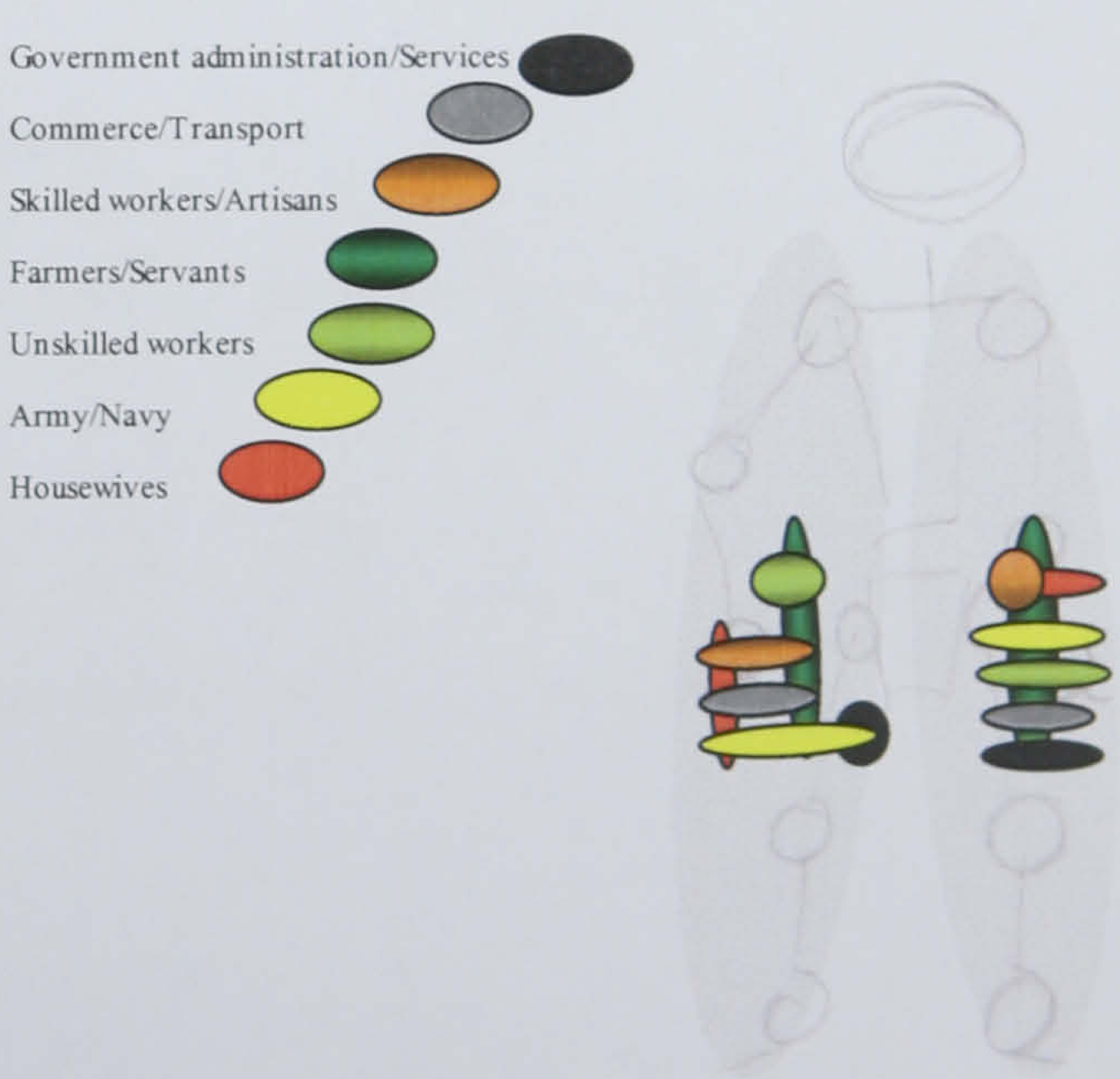


Figure 46 - SumMSM_Total left and right results of pairwise comparisons.

7.1.2 Analysis of SumDBC_MSM variables

The following results concern the second set of Grouped_Variables, in which DBC and MSM were pooled together to form an unique dataset per joint, limb and individual.

7.1.2.1 SumDBC_MSM aggregated variables: summary statistic and bilateral asymmetry

All variables were positively skewed and violated the assumption of normal distribution of the data according to Shapiro-Wilk statistic ($p<0.001$). The majority of individuals had none, or a low value of lesion. The increase in value of lesions per joint, limb and individual reflect the contribution of the different variables. As already observed, when both SumDBC and SumMSM were independently analysed (see section 7.1.1.1), the shoulders and hips joints preserve the highest scores, whilst ankles had the lowest scores (Table 75). When SumDBC_MSM were analysed per limb, higher mean values were obtained for the lower limbs. When analysed per individual (Total_Sum variables) the right side mean value was higher than the left (Table 76).

Table 75 - Descriptive statistics: SumDBC_MSM per joint.

SumDBC_MSM		Left					Right				
		Shoulder	Elbow	Hip	Knee	Ankle	Shoulder	Elbow	Hip	Knee	Ankle
N	Valid	602	599	603	603	603	603	599	603	603	603
	Missing	1	4	0	0	0	0	4	0	0	0
Mean		8.601	4.000	7.713	6.017	2.609	8.975	4.611	7.856	6.259	2.697
Std. Deviation		8.519	4.972	5.847	5.826	2.512	8.381	5.480	5.406	6.206	2.481
Skewness		1.225	2.092	0.548	1.552	0.866	1.159	1.850	0.727	1.601	0.926
Std. Error of Skewness		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Minimum		0	0	0	0	0	0	0	0	0	0
Maximum		44	35	29	37	11	42	32	30	32	13

Table 76 - Descriptive statistics: SumDBC_MSM_Total_Upper and lower limbs, and left and right Total_Sum variables.

		SumDCB_MSM_Total						Total_Sum	
		Upper_left	Upper_right	Lower_left	Lower_right			Left	Right
N	Valid	603	603	603	603	N	Valid	603	603
	Missing	0	0	0	0		Missing	0	0
Mean		14.367	15.488	17.189	17.564	Mean		31.556	33.051
Std. Deviation		13.784	14.444	12.895	12.564	Std. Deviation		25.142	25.205
Skewness		1.097	1.164	0.704	0.744	Skewness		0.784	0.785
Std. Error of Skewness		0.100	0.100	0.100	0.100	Std. Error of Skewnes		0.100	0.100
Minimum		0	0	0	0	Minimum		0	0
Maximum		71	85	66	60	Maximum		123	121

Significant side differences were found in SumDBC_MSM shoulder and elbow, with a clear right side dominance. In the lower limb joints the hips, knees and ankles showed no statistical significance between right and left sides (Table 77). Although separately the joints from the lower limb showed no significant bilateral asymmetry, when lower limb was considered as "total" (SumDBC_MSM_Lower limb) significant bilateral asymmetry was present (Table 77): right side limbs had higher values than left. Bilateral asymmetry was also significant in Total_Sum (Z=-4.578, p<0.001), again with right side dominance.

When bilateral asymmetry was tested per sex sub-sample, men revealed a higher number of significant side differences in the joints (non-significance was only obtained in the knee; Z=-0.792, p=0.432), whilst significant side asymmetry in women was only found in the elbow (Z=-3.824, p<0.001) (Table 78). Upper and lower limb tests showed the absence of difference between left and right sides in women, whereas differences were significant in mens' limbs (Table 79). Right side dominance prevailed in all the significant results obtained. In the Total_Sum variable only men showed a distinctive right side dominance (Z=-5.194, p<0.001); non-significant different was found in females (Z=-1.334, p=0.180).

Table 77 - Wilcoxon signed rank test results: bilateral asymmetry on SumDBC_MSM per joint and upper and lower limbs.

		SumDBC_MSM Shoulder	SumDBC_MSM Elbow	SumDBC_MSM Hip	SumDBC_MSM Knee	SumDBC_MSM Ankle	SumDBC_MSM Upper	SumDBC_MSM Lower
Z		-2.477	-4.995	-1.311	-1.514	-1.337	-4.577	-2.114
Monte Carlo Sig. (2-tailed)		0.015	<0.001	0.189	0.136	0.184	<0.001	0.036
99% Confidence Interval	Lower Bound	0.012	<0.001	0.179	0.127	0.174	<0.001	0.031
	Upper Bound	0.018	<0.001	0.199	0.145	0.193	<0.001	0.041

Table 78 - Wilcoxon signed rank test results: bilateral asymmetry on SumDBC_MSM per sex sub-samples.

		Females - SumDBC_MSM					Males - SumDBC_MSM				
		Shoulder	Elbow	Hip	Knee	Ankle	Shoulder	Elbow	Hip	Knee	Ankle
Z		-0.095	-3.824	-0.209	-1.301	-0.360	-3.555	-3.256	-2.095	-0.792	-2.096
Monte Carlo Sig. (2-tailed)		0.925	<0.001	0.838	0.197	0.721	<0.001	0.001	0.032	0.432	0.035
99% Confidence Interval	Lower Bound	0.919	<0.001	0.828	0.187	0.709	<0.001	<0.001	0.027	0.419	0.030
	Upper Bound	0.932	0.001	0.847	0.207	0.732	0.001	0.002	0.036	0.445	0.039

Table 79 - Wilcoxon signed rank test results: bilateral asymmetry according to upper and lower limbs per female and male sub-samples.

SumDBC_MSM		Female Sample		Male Sample	
		Upper	Lower	Upper	Lower
Z		-1.704	-0.636	-4.682	-2.430
Monte Carlo Sig. (2-tailed)		0.088	0.523	<0.001	0.013
99% Confidence Interval	Lower Bound	0.080	0.510	<0.001	0.010
	Upper Bound	0.095	0.536	<0.001	0.016

7.1.2.2 SumDBC_MSM aggregated variables: analysis according to sex of the individuals

Several statistically significant results were found between men and women in various variables (Tables 80 and 81), with women always presenting the higher mean scores. However, according to the hierarchical regression results, when controlling for age and sex, sex became non-significant in all accounts, whilst age emerged as the sole significant predictor for lesions. Therefore, it can be can be concluded that male and females differences were more related to the older age of the female sub-sample and not to a particular sex predisposition, at least in this sample (see section 1.1.4.2 in Appendix_Grouped_Variables).

Table 80 - Mann-Whitney statistical test results: sex differences in SumDBC_MSM joint variables.

SumDBC_MSM		Left					Right				
		Shoulder	Elbow	Hip	Knee	Ankle	Shoulder	Elbow	Hip	Knee	Ankle
U		43334.500	42337.500	40511.000	41331.500	39987.500	44549.500	41048.000	41986.000	40841.000	42098.000
Z		-0.923	-1.201	-2.313	-1.932	-2.591	-0.422	-1.814	-1.622	-2.162	-1.587
Monte Carlo Sig. (2-tailed)		0.350	0.228	0.021	0.053	0.010	0.679	0.073	0.100	0.031	0.111
99% Confidence	Lower Bound	0.338	0.217	0.017	0.047	0.007	0.667	0.066	0.092	0.027	0.103
Interval	Upper Bound	0.362	0.239	0.025	0.059	0.012	0.691	0.079	0.108	0.036	0.119

Table 81 - Mann-Whitney statistical test results: sex differences SumDBC_MSM_Total_Upper and lower limbs and in the Total_Sum.

SumDBC_MSM		Left		Right	
		Upper	Lower	Upper	Lower
U		43556.5	40286	45302.5	40999.5
Z		-0.886	-2.415	-0.069	-2.082
Monte Carlo Sig. (2-tailed)		0.370	0.014	0.948	0.035
99% Confidence	Lower Bound	0.357	0.011	0.943	0.030
Interval	Upper Bound	0.382	0.017	0.954	0.040

Total_Sum		Left	Right
U		41590.5	43072
Z		-1.805	-1.112
Monte Carlo Sig. (2-taile		0.069	0.268
Confidence	Lower Bou	0.062	0.256
Interval	Upper Bou	0.075	0.279

7.1.2.3 SumDBC_MSM aggregated variables: analysis according to age at death of the individuals

The Kruskal-Wallis test proved the existence of a significant relationship between some occupational groups and the variables under study (Tables 47 and 48; Appendix_Grouped_Variables). Once more, and because this test did not consider the influence of age in the results, nor specify where the differences lied between groups, ANCOVA tests as well as post hoc pairwise comparisons were performed. The results showed that age continues to be the major factor in the interpretation of degenerative lesions. A significant effect of occupation was found on the right shoulder (SumDBC_MSM), right upper limb (SumDBC_MSM_Upper) and right side (Total_Sum) ($p<0.050$) (Tables 82 to 83).

Table 82 - ANCOVA test results: SumDBC_MSM.

SumDBC_MSM_Left		df	F-value	Sig.	SumDBC_MSM_Right		df	F-value	Sig.
Shoulder	Age	(1,594)	520.775	<0.001	Shoulder	Age	(1,595)	520.224	<0.001
	Occupation	(6,594)	0.795	0.574		Occupation	(6,595)	3.890	0.001
Elbow	Age	(1,591)	282.245	<0.001	Elbow	Age	(1,591)	374.698	<0.001
	Occupation	(6,591)	0.356	0.906		Occupation	(6,591)	0.610	0.723
Hip	Age	(1,595)	764.870	<0.001	Hip	Age	(1,595)	625.404	<0.001
	Occupation	(6,595)	1.459	0.190		Occupation	(6,595)	1.612	0.141
Knee	Age	(1,595)	344.428	<0.001	Knee	Age	(1,595)	309.296	<0.001
	Occupation	(6,595)	0.789	0.579		Occupation	(6,595)	1.537	0.164
Ankle	Age	(1,595)	149.763	<0.001	Ankle	Age	(1,595)	151.386	<0.001
	Occupation	(6,595)	0.967	0.446		Occupation	(6,595)	0.408	0.874

Table 83 – ANCOVA test results: SumDBC_MSM_Total_Upper and lower limb.

SumDBC_MSM_Total Left		df	F-value	Sig.	SumDBC_MSM_Total Right		df	F-value	Sig.
Upper	Age	(1,595)	620.773	<0.001	Upper	Age	(1,595)	651.667	<0.001
	Occupation	(6,595)	1.047	0.394		Occupation	(6,595)	3.217	0.004
Lower	Age	(1,595)	721.203	<0.001	Lower	Age	(1,595)	647.053	<0.001
	Occupation	(6,595)	1.147	0.333		Occupation	(6,595)	1.489	0.180

Table 84 - ANCOVA test results: Total_Sum.

Total_Sum_Left	df	F-value	Sig.	Total_Sum_Right	df	F-value	Sig.
Age	(1,595)	878.396	<0.001	Age	(1,595)	887.350	<0.001
Occupation	(6,595)	1.083	0.371	Occupation	(6,595)	2.230	0.039

Post hoc pairwise comparisons, performed on the variables where occupational group was found to be significant, showed that the major differences revolved around the groups of government administration and services, farmers and servants, and housewives which possessed the lower mean values; and unskilled workers, and army and navy group with the highest mean values. Isolated significant interactions were found in the remaining groups (commerce and transport, and skilled workers and artisans). When significance was found between these groups and the remaining cases, they exhibited higher value than their counterparts.

In summary, the major differences found between occupational groups were:

- SumDBC_MSM_Right_Shoulder - people working in transport and commerce, unskilled workers and individuals of the armed forces differed significantly from people employed in government administration, services, and as farmers, servants and housewives (Figure 47):

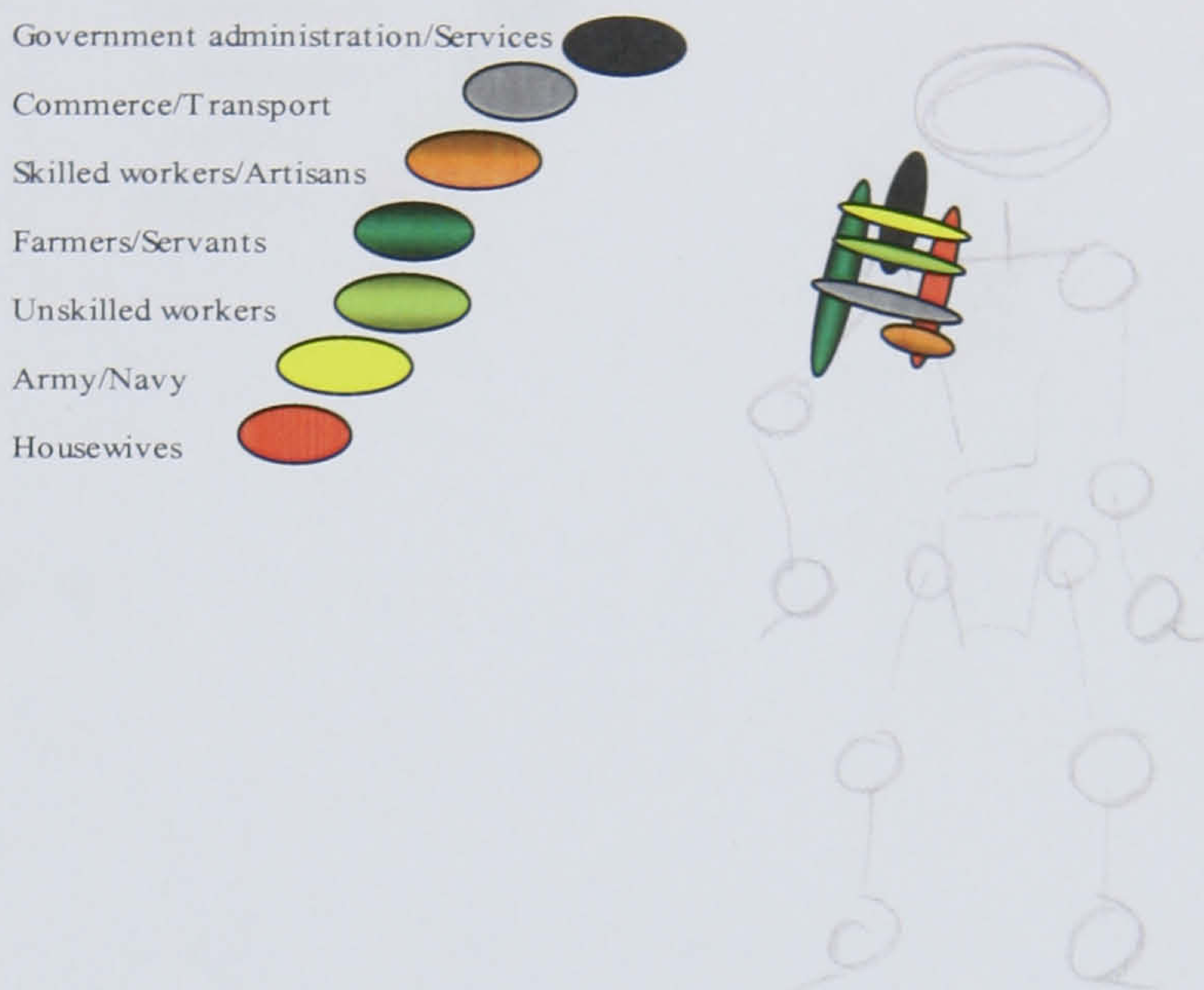


Figure 47 -
SumDBC_MSM_Right_Shoulder results of pairwise comparisons.

- SumDBC_MSM_Total_Upper_Right - similar to the above, individuals involved in unskilled crafts and the armed forces differ significantly from people working in government administration, as farmers, servants and housewives; housewives were also significantly different from people working in commerce, transport, armed forces and unskilled labour (Figure 48):

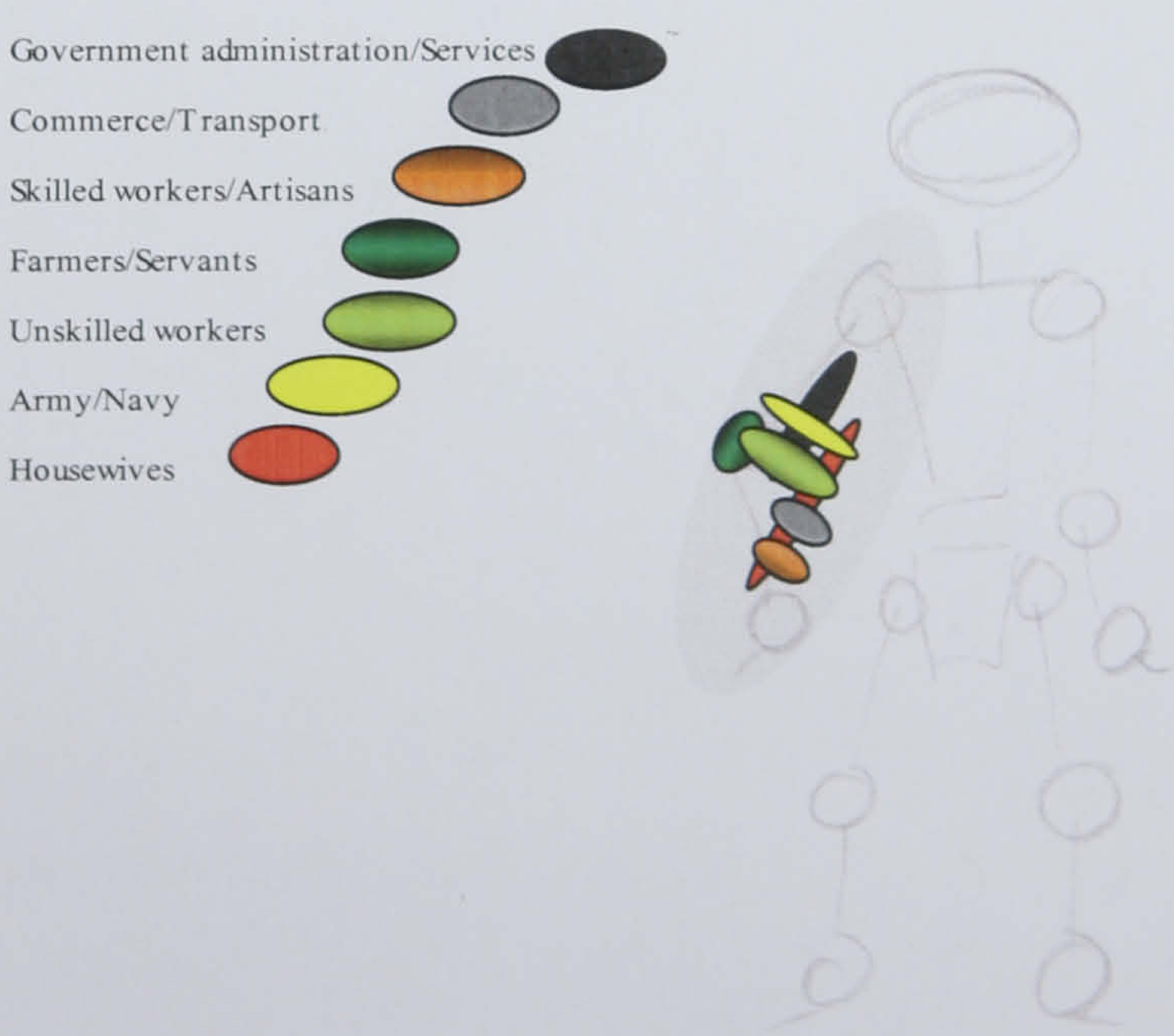


Figure 48 –
SumDBC_MSM_Total_Upper_Right results of pairwise comparisons.

- Total_Sum_Right - the major differences were found between individuals occupied in commerce and transport, and the armed forces, which showed higher mean values (Figure 49).

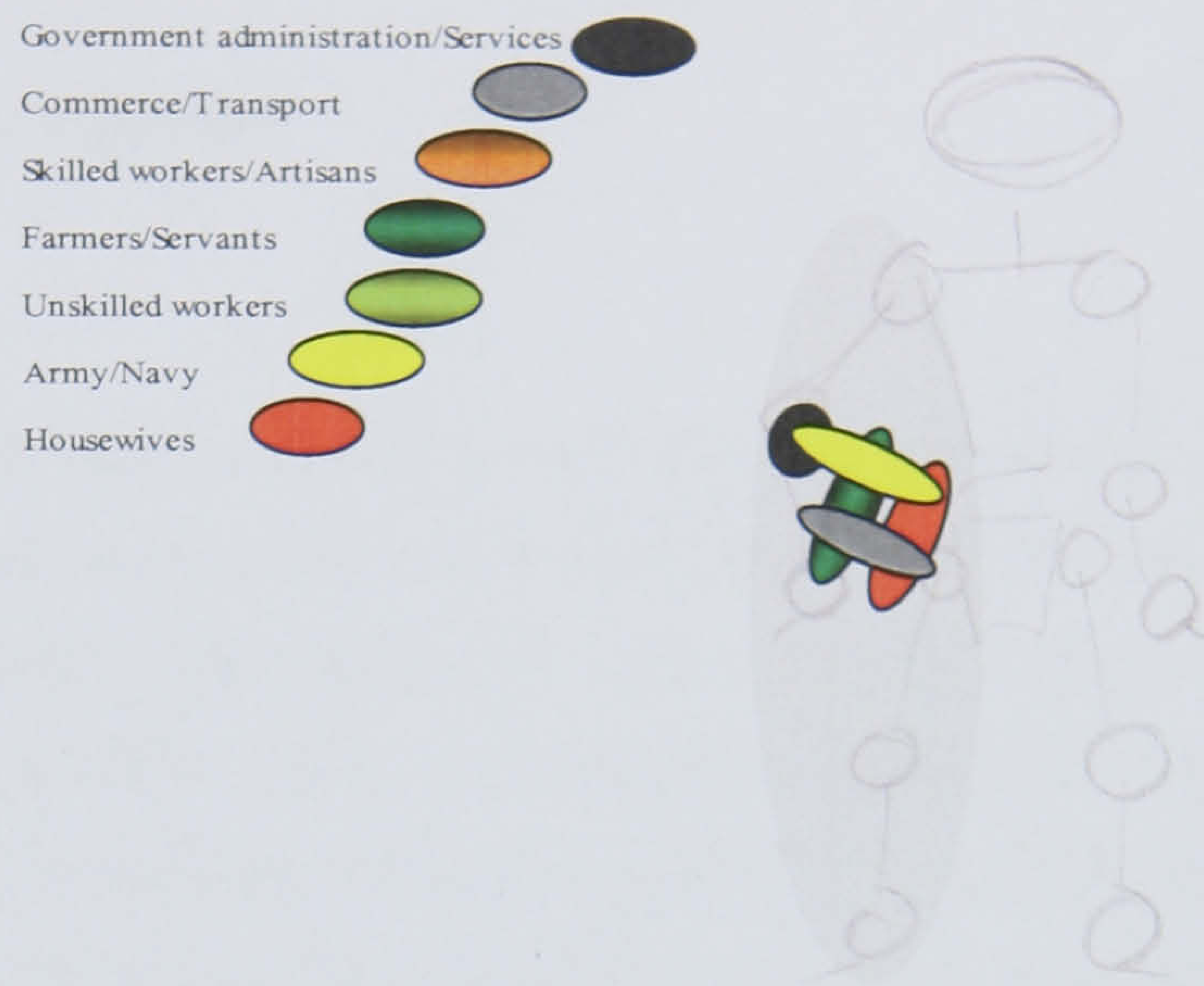


Figure 49 – Total_Sum_Right results of pairwise comparisons.

7.1.3 Summary and discussion of the results of Grouped_Variables

7.1.3.1 Summary of results of Grouped_Variables

The analysis of the Sum variables showed higher scores of lesion associated with shoulders and hips joints. Lowest scores were found on the ankles and wrists. This was true for both SumDBC and SumMSM. Right side variables had significantly higher scores than left side variables. When bilateral asymmetry was tested in the sex-sub-sample, significance was mostly associated with male individuals. Significant bilateral asymmetry was particularly found on the SumDBC variables. In the SumMSM significant asymmetry was only achieved for the elbow (section 7.1.1.1.1).

As a rule, women accounted for the higher scores of lesions in both types of sum variables, although not all joints exhibited sex-specific significant results (section 7.1.1.1.2). Further testing into the sex differences revealed that the significance levels achieved were related with the female sub-sample's older age, and were not an expression of sex-specific patterns of lesions. Hence, age was a major source of bias, both in sex sub-sample as well as occupational groups.

The majority of SumDBC and SumMSM, and consequently the remaining grouped_variables, revealed a significant association with age at death. Nevertheless, it was possible to ascertain that in certain sum variables the "occupational group" category was also a significant predictor of lesions. For instance, SumDBC on the right shoulder, right ankle and hips revealed to be significantly related with the age at death of the individuals, and with their occupational activity. In these joints, individuals employed in activities linked to commerce and transports, or that worked as unskilled workers possessed the highest mean values of lesions, when compared to the other occupational groups. In SumMSM variables, individuals categorized as unskilled workers, skilled workers and artisans, and armed forces employees had higher scores of lesions. Individuals employed in agriculture and as servants, and housewives, consistently exhibited low mean values. The number of significant results observed for SumMSM was higher than the one obtained for SumDBC.

When data was grouped per limb, the overall pattern of bilateral asymmetry, with right-side dominance, female significance and age at death association was maintained. Occupational groups were found to significantly contribute to SumMSM in the upper limbs, but not to SumDBC changes. SumMSM differences focused on the farmers and servants group, which had a statistically significant lower mean value of lesions, when compared to the remaining occupations. The housewives groups, as well as government administration and services, proved to be of occasional significance, with low scores of lesions. In SumDBC_Total commerce and transport, and unskilled workers had higher mean values, on the right side. SumMSM_Total occupational group differences were bilaterally significant: farmers and servants, and housewives possessed the lower mean values. The results found for SumDBC_Total and SumMSM_Total were similar to the results achieved when the variables were considered per joint, slightly different to the ones obtained for the limbs analysis. For example, the analysis of bilateral asymmetry in joints showed the absence of significant differences between right and left lower limb joints (hip, knee and ankle) (Table 57; section 7.1.1.1.1); however, when lower limbs (resulting from the addition of hip, knee and ankle scores) were tested for bilateral asymmetry, this proved to be significant (Table 66; section 7.1.1.2.1). This significance was mostly related with the male sub-sample.

When the SumDBC and SumMSM variables were pooled together the results obtained were, in all, similar to the ones attained for separate sum variables. There was a clear bilateral asymmetry, particularly in males, which permeated the total sample; right side joints, limb and total scores were higher than lefts. Females continued to have higher mean scores of lesions. However, when age and sex were tested as predictors of sum variables, sex was non-significant, reinforcing the importance of age in the current sample. Regarding occupational groups, interactions with lesions revolved around two major situations: on the one side we found the farmers, servants and a housewives with the lower mean scores; on the other hand all the remaining groups. Unskilled workers and armed forces people were consistently exhibiting the higher mean values.

7.1.3.2 Discussion of results of Grouped_Variables

The findings clarify the fact that depending on the approach to the data, the final conclusions obtained can vary. This reiterated the need for standardization of the protocols of data analysis in bioarchaeological analysis, particularly if the aim of the research is inter-population analysis.

In the current analysis, although the Groups_Variables did not address osteoarthritis (OA), or enthesopathies (MSM) directly, it is possible to establish a discussional bridge between clinical analysis of OA and enthesopathies and the current results. Ultimately, they both convey degenerative changes associated with joints and entheses, commonly used in bioarchaeology to assess/reconstruct activity and behaviour, which was the precise line of inquiry in the current research.

The results achieved contradict, to a certain extent, some of the arguments and results achieved in other bioarchaeological studies. For instance, the statement that a "higher prevalence of osteoarthritis in males than in females is nearly universal, suggesting that workload and mobility - at least as it affects the articular joints – is greater in men than in women in past societies" (Larsen, 2002: 134), may not be as straightforward as stated. First of all, OA prevalence between past populations is intimately related with the methods used (see chapter 3 and 6 for discussion). Secondly, the results achieved in this study showed that if age at death cannot be controlled for, OA assumption may be biased by the age at death of the individuals. In the current research, this scenario was consistently found specifically when sex sub-samples were compared. Therefore, without age control, all conclusions drawn in past populations may have favoured a fictional reality. Fictional, because many of the conclusions drawn can bear a strong relation with the researcher's conceptions of past societies and the individual, rather than with the past societies themselves. This conclusion would be similar to the one described as a "gender mythology" (chapter 2), in the sense that in both situations the real contributions of the original data, may be filtered by the personal, and ethnocentric view of the researcher. If age had not been controlled for in this sample, the sex-related data drawn from the analysis would have been shaped by the idea that, perhaps women in the late 19th and early to mid 20th Portuguese society were more engaged in strenuous activities than men. Such, results would have been erroneous. Females exhibited significantly higher values than men because they were older, and not necessarily because they were engaging more strenuous or repetitive activities. In fact, when DBC and MSM were tested according to occupation groups, the housewife category consistently showed lower scores values, than the remaining occupational categories contradicting the sex-related significant results achieved when comparing sex sub-samples without controlling for age. With this is mind, the importance of advising age controlling statistical analysis is of major importance. The constant reference to age does not automatically exclude the possibility of other non-accounted variables influencing the results. However, it illustrates the fact that many assumptions may lead to erroneous conclusions if one is not careful enough when designing one's model of research, and that if age is not controlled for, one cannot limit the effects of other, non-age related variables.

With regards to bilateral asymmetry, the strong right side dominance, in all types of sum variables, either singular, or grouped, was another consistent finding in the current data analysis. Unsurprisingly, this expressed right handedness in the overall population, based on the fact that the majority of people are right handed (Blackburn and Knüsel, 2006; Holder, 2001). The rotational between the association of right handedness, and the degenerative lesions analysed is that the overuse of right hand side joints and limbs implies more movements/activity of those joints and muscles, when compared to left ones, and consequently more degenerative changes can be perceived as activity-related.

The fact that significant lesions were mostly found in the upper limbs, when scores were combined, tied comfortably with the notion that lower limbs may express bipedal related changes rather than occupational related ones. The lower limb association with bipedal locomotion would allow for symmetrical balance between limbs, and exposition to mechanical constraints, whilst occupation related involvement of upper limb would favour a wider asymmetry of results (Leiberman *et al.*, 2001; Plochocki, 2004). That being the case, the upper limbs would be/are more suitable candidates to address activity-related differences between human populations, occupations or specific activities, as locomotion, weight bearing and postural support do not have a direct relationship with them. It was curious to observe that when values were grouped per limb, significant results were found that were non-existent if joints of the limb were considered separately. This may suggest that if the objective of a research is to assess upper and lower limb differential use in activity, it is necessary to consider the limb as a whole, and not a selected bone, joint or insertion site. As proven by the current research, the selection of a particular single joint to assess the overall upper and lower limb association may provide inaccurate results.

One of the major results achieved in the analysis of Grouped_Variables was that these did not conform with the assumption that individuals engaged in "so called" more physically strenuous occupations would exhibit the higher values of degenerative bony changes, either on the joints or on the muscular insertion sites. The occupational groups that supposedly were exposed to a higher level of mechanical stress exhibited some of the lower mean estimated values. This was the case found for individuals working as farmers and servants. These mean values were calculated after controlling for age, the known confounder in the current research. This data refutes, to a certain extent, clinical trails which prove that farmers have a high prevalence of OA (Jordan *et al.*, 1995). One could argue that the sum variables analysed in the current research are not the best proxy for OA comparisons, as they have considered all degenerative bone changes found in the articular surfaces, as well as muscular insertions sites (under study). Nevertheless, this issue is worthy of discussion since, if OA is assisted with degenerative articular changes, these were accounted for in the current research, hence some comparative basis is possible.

There are many clinical studies that focus on the analysis of occupations and prevalence of OA, particularly in the knee and hip joints (amongst them: Gramstad and Galatz, 2006; Jordan *et al.*, 1995; Rossignol, 2004; Rossignol *et al.*, 2005; Rossignol *et al.*, 2003). Rossignol and colleagues research pointed out that female cleaners, and women working in the clothing industry and agriculture, had the greatest prevalence rates of OA, and that highest prevalence rates were found in male masons, or those working in other construction activities or in farming (Rossignol *et al.*, 2005). Statistically significant associations were found in activities where physically demanding performance involves a heavy workload, lifting, climbing, kneeling, squatting and bending (Rossignol, 2004). In this sample individuals that were categorized as farmers and servants, and female individuals (housewives) displayed the lower mean values of lesions throughout the entire Grouped_Variable analysis. On the other hand, unskilled workers were amongst the occupational groups with the higher values of lesions, closely followed by people working in commerce and transport. Other isolated cases of significance between occupational groups and sum variables events were found, but the majority of the significant associations, and differentiations between occupational groups orbited around the mentioned groups, with particular relevance to the pattern of occupational categories which systematically exhibited the highest and lowest mean values: unskilled workers *verus* farmers and servants, and housewives (for descriptive statistics of the sum variables per occupational group (see Table 49; Appendix_Grouped_Variables).

In the current study, specific occupational physical performance demands, such as manual work, knee bending, lifting, heavy handing, repetitive motion, and force with tools, were not considered, neither was the sum of years of the activity. To do so would require more detailed analysis of the physical "preformative demands" of the activities under analysis, with scrupulous recording of specific physical acts. Future analysis focused on occupation should consider this dimension of analysis, as several clinical studies have found significant lesions between specific and repetitive mechanical behaviours, such as the ones described above, and OA (McAlindon *et al.*, 1999; Petersson and Jacobsson, 2002).

The lack of information on the "performative demands" of the activities under analysis did not prevent the identification of patterns of sum variables' intensity scores, which reflected the degree of degenerative changes observed. In general, the hierarchy of affection of joints, from highest to lowest lesion value, was shoulder, hip and knee. This was observed for almost all occupational groups. In the case of the farmers and servants, unskilled workers and housewives, the hierarchy was slightly different; in these cases the third most affected joints were the elbows and not the knees. These differences, although small, may be indicative of some specific "preformative demand", however to ascertain such an hypothesis, further testing is necessary.

If the hierarchy of lesion intensity is analysed according to limbs, different patterns are observed for SumDBC and SumMSM. In the first case, the major differences are observed between limbs laterality, right *versus* left, and not between upper and lower. This pattern was observed for the majority of the occupational groups, the exception being that of farmers and servants, unskilled workers and housewives. In these cases, the difference is found between upper and lower limbs, regardless of side. The analysis of SumMSM variables revealed that major differences were found between lower and upper limbs, with higher scores recorded on the first. This pattern was observed for all occupational categories, with the exception of unskilled workers. They exhibited higher score values on the lower left and upper right limbs.

The results of the SumDBC_MSM variables showed the overall pattern found in the individual analysis performed: shoulder, hip and knee had the higher scores in the majority of occupational groups, as did the lower limbs; all of them appertained to the right side. Once more, the exception found was for the occupational groups containing farmers, servants and unskilled workers. In these categories hip, shoulder and elbow exhibited the higher values of lesions. Further, lower limbs had higher values than upper for all occupational groups, with the exception of unskilled workers. In all accounts right side scores were higher than left (detailed descriptive statistics of all these values can be found in Table 49, Appendix_Grouped_Variables).

The overall difference between sites observed, joints, limbs and sides, were tested within occupational groups, and in almost all cases the values of the Friedman and the Wilcoxon statistical test revealed that the mean differences between joint site affected were statistically significant in SumDBC and SumMSM variables ($p<0.001$). This revealed that if joints and muscular insertions sites lesions reflect their differential usage, shoulders, hips and knees were engaged in proportionately more activity. Significant differences between upper and lower limbs were obtained for the occupational groups of commerce and transport, skilled workers and artisans, and army and navy personnel ($p\leq0.05$) for SumDBC in limbs. In the SumMSM limb variables, the only occupational group that did not exhibit statistical significant differences between limbs was that of unskilled workers ($p=0.104$). Further, when the total value of SumDBC and SumMSM were tested in the former commerce and transport, unskilled workers and army/navy groups showed overall statistical significant difference in values ($p<0.05$); in the latter, overall significant differences were found in the skilled workers and artisans, farmers and servants, and army/navy personnel ($p<0.05$). The results achieved when the sum variables were analysed together (SumDBC_MSM), revealed that all occupational groups consistently showed significant statistical values when joints, limbs or overall values were compared ($p<0.05$). The exception was found for the total value in the housewife category ($p=0.157$) (detailed statistical test results can be consulted in section: 1.4.5, Appendix_Grouped_Variable). In all, the fact that almost all groups showed significant values of degenerative bony changes intensity, throughout the variables analysed, precludes the inference of any occupational group specific-pattern.

One could argue that the apparent lack of occupational groups' specificity may be related with the fact that these groups hide occupational-specific changes that otherwise could be used to identify, or reconstruct, specific professions or performative activity-related changes. For instance, some occupations are an excellent context to test if: 1) specific occupations exhibit differential patterns of lesions: 2) if there is a significant difference between individuals engaged in manual work *versus* individuals engaged in what could be perceived as non-manual work. To test this hypothesis a group of 48 male individuals was selected. Distribution of these individuals according to their occupation, and descriptive statistics of their age at death can be consulted in Table 85. Kruskal-Wallis test was performed to determine if the sum variables were significantly different between these occupations. The results showed no statistically significant difference between these specific occupations and the sum variables, that is, based on the sum variables analysed no specific pattern of lesions was found between civil servants, shoemakers, carpenters and bricklayers. Furthermore, the so called manual workers did not differ from the non-manual ones (civil servants). Detailed tests results of the variables analysed can be consulted in Appendix_Grouped_Variables (section: 1.4.6).

Table 85 – Descriptive statistics of age at death.

	N	%	Minimum	Mean	Maximum	Std. Deviation
Civil servant	13	27.08	30	60.54	82	16.78
Shoemaker	12	25.00	24	49.67	78	18.23
Carpenter	15	31.25	23	49.27	83	20.14
Bricklayer	8	16.67	23	49.63	74	20.69
Total	48	100	23	52.48	83	18.94

A major issue with the analysis of occupational related degenerative changes is the lack of a complete biography of the individuals under analysis. The occupation at time of death might not have been the original occupation of the individual, plus, she/he could have performed several activities during his/her lifetime. These cases were illustrated in the Lisbon collection (LLSC), in which several cases were recorded of individuals changing occupation during their lifetime (Cardoso, 2005).[63] It was also impossible to determine when a person would have started to work. If one was to consider the overall historical and social context of Portuguese society, most probably the majority of the individuals of lower social economic status would have started working at a very young age, and this factor would certainly have an impact upon the presence of degenerative changes.

Another major problem in the analysis of occupational related degenerative changes was the overall classification of the women as housewives. A better distinction between the working women and the non-working women was impossible to accomplish with the current data available. This had major consequences for the primary objective of the current research, which was portraying gender in the 19th and 20th Portuguese society. Despite the overall lack of occupation-specifics with regard to women, it was possible to infer that: when the sum variables were analysed individually per type of lesion (DBC *versus* MSM) the housewives category shared many similarities with the occupational group of farmers and servants. This was particularly true when joints and limbs were analysed. In all, women exhibited one of the lower scores of degenerative changes.

In summary, the main findings of this study were firstly, that sex, and age at death were intimately related, and could bias the interpretation of the Grouped_Vartiables results; secondly, there exists a clear right-side handedness throughout the variables; thirdly, the consideration of the sum variables per joints, limbs or as a "total score", provided different results; and finally, the occupational group differences varied throughout the various sum variables. When controlling for age, occupation had no significant relation with the outcome variables in the majority of cases; nevertheless, it was possible to identify a few situations where age at death, and occupation played a significant role in the outcome, and severity, of lesions. Patterns of significance between occupational categories orbited around farmers and servants, and housewives, with the overall lower scores, whilst unskilled workers and individuals employed in commerce and transport generally possessed higher scores.

[63] The author referred to at least four cases of parents (father) that changed occupation between the birth and death of their children.

7.2 Analysis of Indices

The following section deals with the results of the analysis of the postcranial indices calculated for several long bones. The description and relevance of the indices was described in the methods chapter (4). The results focus on the indices of Robusticity (RI), Platymeric and Platycnemic (PI), and Diaphyseal (DI). The analysis will test skeletal collections, sexes and occupational groups' sub-samples differences. Age at death correlation with indices was also analysed. Bilateral asymmetry was tested in all steps of the analysis.

7.2.1 Indices: summary statistics and bilateral asymmetry

The descriptive statistics of the indices calculated can be consulted in Table 86. With the exception of RI in the humeri and femurs, bilateral asymmetry was statistically significant in the remaining indices. The ulnas and radii had higher indices values for the left side bones, whilst the remaining bones presented higher values on the right side. RI in the femurs and tibiae and DI in the ulnas tests were conducted using the Wilcoxon statistical test, since the data had a non-normal distribution.[64] As can be observed in Figures 50 and 51, the present of outliers was constant in all indices, although only one case was registered as extreme, in the RI of the right femur.

[64]Whenever data presented a non-normal distribution, instead of using the paired *t-test*, the Wilcoxon statistical test was employed instead.

Table 86 - Summary statistics of the indices for each of the long bones (pooled samples) and paired *t-test* and Wilcoxon results.

	Left					Right							
	N	Min.	Max.	Mean	S.d.	N	Min.	Max.	Mean	S.d.	*t-test*	df	*P*
Robusticity Index													
Humerus	566	15,43	25,31	19,85	1,451	568	15,65	26,67	19,93	1,519	-1,357	546	0,175
Radius	540	14,54	22,77	18,41	1,479	538	14,23	22,37	18,22	1,405	2,912	487	0,004
Ulna	489	11,30	18,78	14,86	1,250	495	10,67	18,60	14,95	1,243	-2,326	442	0,020
											Wilcoxon		
Femur	578	16,44	25,14	20,13	1,235	590	16,50	25,93	20,08	1,227	-0,735		0,468
Tibia	575	15,94	25,49	20,65	1,454	567	14,98	26,53	20,66	1,494	-2,052		0,043
Platymeric (femurs) Platycnemic (tibiae) indexes													
Femur	590	62,17	115,67	85,14	7,966	598	61,97	120,14	87,13	8,112	-9,035	586	<0.001
Tibia	597	58,07	93,86	73,83	5,866	596	55,85	101,84	74,49	6,191	-3,888	592	<0.001
Diaphyseal Index													
Humerus	585	71,21	117,61	91,23	7,648	590	72,08	116,89	94,12	7,611	-10,750	578	<0.001
Radius	586	54,38	98,33	75,49	6,640	585	54,89	97,13	73,87	6,813	7,535	570	<0.001
Femur	594	75,83	133,28	106,10	9,032	599	77,58	135,13	107,90	8,900	-8,310	590	<0.001
											Wilcoxon		
Ulna	583	58,24	102,40	76,99	6,775	587	59,20	101,30	75,47	6,150	-6,474		<0.001

N – number of cases; Min – minimum value; Max.- maximum value; S.d. – standard deviation value. Monte Carlo, two-tailed significant test used.

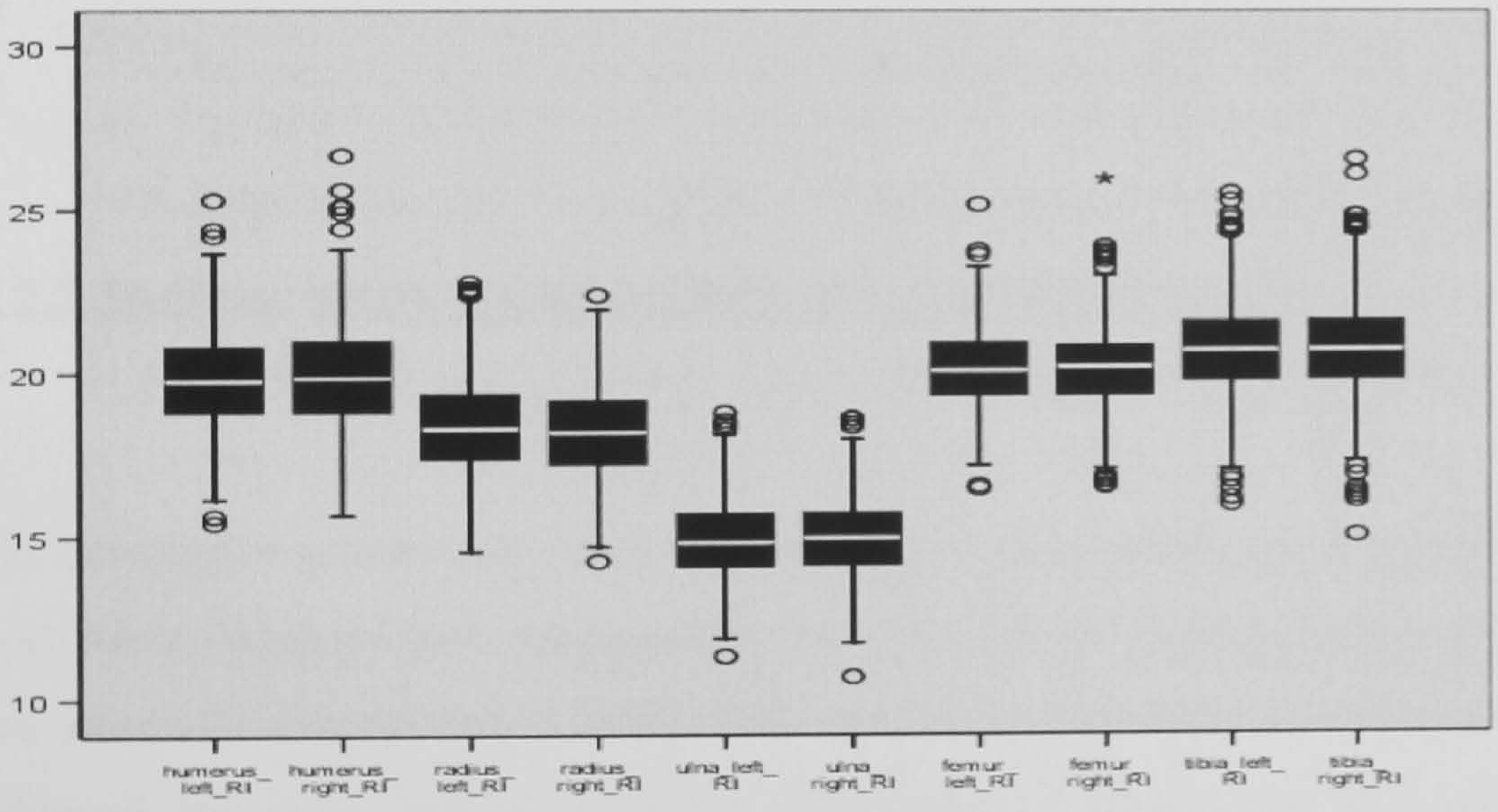


Figure 50 - Boxplots of RI indices according to bones analysed (Y-axis represent the index values). The median is represented by the line in the box. The box includes 50% of the distribution, the whiskers represent the non-outlier range of the distribution and the circles the outlier values. Only one case represents an extreme outlier value (*in the RI of the right femur).

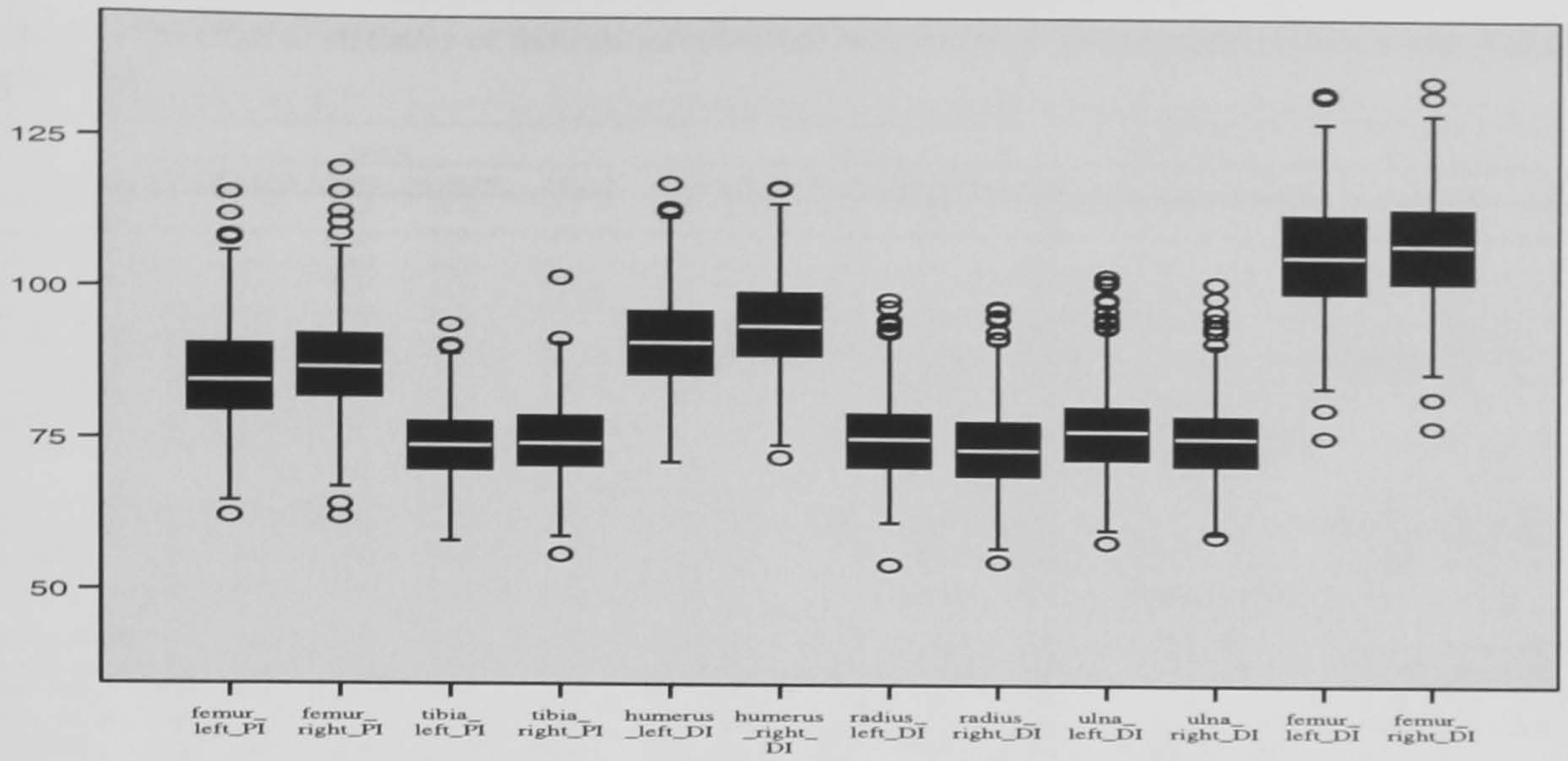


Figure 51 - Boxplots of the PI and DI indices according to bones analysed (Y-axis represent the index values). The median is represented by the line in the box. The box includes 50% of the distribution, the whiskers represent the non-outlier range of the distribution and the circles the outlier values.

7.2.2 Indices: analyses according to skeletal collection

The descriptive statistics of indices per collection sub-sample can be consulted in Table 87. Both Mann-Whitney and independent t-test results were presented, as some variables were not normally distributed.[65] Statistical significance differences between indices were achieved for most indices ($p<0.05$). The higher scores were obtained for the CISC (Coimbra), with the exception of the femurs PI and the radii DI, in these cases the LLSC (Lisbon) had higher scores. Marginal levels of significance were also found for RI of the right humerus ($p=0.051$) and for DI of the right radius ($p=0.068$).

[65] Mann-Whitney statistical test replaced the independent t-test whenever variables were not normally distributed.

Table 87 - Descriptive statistics of indices, per skeletal collection sub-sample, and statistical test results of mean comparison.

	Lisbon					Coimbra					Mann-Whitney test		Independent t-test		
	N	Minimum	Mean	Maximum	S.d.	N	Minimum	Mean	Maximum	S.d.	U	P	t	df	P
Humerus_left_RI	275	15,43	19,72	24,40	1,39	291	15,63	19,98	25,31	1,50	-	-	[illegible]	564	0.036
Humerus_right_RI	280	15,65	19,80	25,08	1,43	288	16,44	20,06	26,67	1,60	-	-	-1,958	566	0,051
Radius_left_RI	253	14,54	18,19	22,32	1,35	287	14,93	18,60	22,77	1,56	-	-	-3.2166*	537,6	0,001
Radius_right_RI	252	14,75	18,19	22,37	1,34	286	14,23	18,26	21,93	1,46	-	-	-0,6	536	0,548
Ulna_left_RI	213	11,30	14,54	18,00	1,19	276	12,28	15,12	18,78	1,24	-	-	-5,237	487	<0.001
Ulna_right_RI	218	11,72	14,66	18,58	1,18	277	10,67	15,18	18,60	1,24	-	-	-4,799	493	<0.001
Femur_left_RI	285	17,16	20,09	25,14	1,25	293	16,44	20,17	23,59	1,22	-	-	-0,877	576	0,381
Femur_right_RI	294	16,67	20,05	23,61	1,19	296	16,50	20,12	25,93	1,27	42460,5	0,612	-	-	-
Tibia_left_RI	283	17,38	20,43	24,84	1,28	292	15,94	20,86	25,49	1,58	33126,5	<0.000	-	-	-
Tibia_right_RI	278	16,84	20,44	24,81	1,31	289	14,98	20,88	26,53	1,62	32379,5	<0.000	-	-	-
Femur_left_PI	296	65,38	86,25	115,67	7,85	294	62,17	84,03	108,25	7,94	-	-	3,479	588	<0.001
Femur_right_PI	301	68,49	88,36	116,08	7,97	297	61,97	85,89	120,14	8,08	-	-	3,766	596	<0.001
Tibia_left_PI	301	58,07	73,51	90,45	6,19	296	60,30	74,15	93,86	5,50	-	-	-0,1338	595	0,181
Tibia_right_PI	299	55,85	73,97	91,58	6,31	297	59,74	75,02	101,84	6,04	39785,0	0,030	-	-	-
Humerus_left_DI	291	76,06	91,61	112,90	7,67	294	71,21	90,84	117,61	7,62	-	-	1,221	583	0,223
Humerus_right_DI	296	72,08	93,39	116,89	7,52	294	74,15	94,83	114,26	7,64	-	-	-2,296	588	0,022
Radius_left_DI	289	61,37	77,28	98,33	7,12	297	54,38	73,76	90,36	5,63	-	-	6,629	548	<0.001
Radius_right_DI	289	57,22	76,32	97,13	6,69	296	54,89	71,48	91,24	6,05	-	-	9,226	583	<0.001
Ulna_left_DI	288	58,24	76,54	102,40	6,70	295	63,14	77,44	101,65	6,83	39348,0	0,128	-	-	-
Ulna_right_DI	293	61,03	75,05	101,30	5,89	294	59,20	75,90	96,61	6,38	39356,0	0,068	-	-	-
Femur_left_DI	296	80,50	105,85	133,28	8,88	298	75,83	106,31	127,61	9,19	-	-	-0,611	592	0,541
Femur_right_DI	301	82,42	108,00	129,69	8,51	298	77,58	107,95	135,13	9,29	-	-	0,077	597	0,939

P - Two-tailed level of significance;* - equal variance not assumed according to Levene's Test for Equality of Variances. Mann Whitney statistical test results were only presented for the variables where the independent t-test could not be used

Several statistically significant bilateral asymmetries were found (Table 88), most of them exemplified a right side dominance of upper and lower limbs. Exceptions were found for the DI of the radii and ulnas, in which left side bones had higher index values.

Table 88 –Indices bilateral asymmetry according to skeletal collection.

	Lisbon collection						Coimbra collection					
	Wilcoxon test		Paired t-test			Side dominance	Wilcoxon test		Paired t-test			Side dominance
Index	Z	P	t	df	p		Z	P	t	df	p	
RI_Humeri	-	-	-0.650	263	0.517		-	-	-1.191	282	0.235	
RI_Radii	-	-	0.366	211	0.715		-	-	3.775	275	<0.001	Left > Right
RI_Ulnas	-	-	2.166	174	0.032	Right > Left	-	-	1.319	267	0.188	
RI_Femurs	-	-	0.189	276	0.085		-1.783	0.075	1.500	290	0.135	
RI_Tibiae	-	-	-0.607	266	0.544		-2.166	0.032	-	-	-	Right > Left
PI_Femurs	-	-	-6.579	292	<0.001	Right > Left	-	-	-5.996	293	<0.001	Right > Left
PI_Tibiae	-	-	-1.646	297	0.101		-4.088	<0.001	-	-	-	Right > Left
DI_Humeri	-	-	4.498	286	<0.001	Right > Left	-	-	-10.86	291	<0.001	Right > Left
DI_Radii	-	-	2.849	275	0.005	Left > Right	-	-	7.520	294	<0.001	Left > Right
DI_Ulnas	-4.304	<0.001	-	-	-	Left > Right	-4.815	<0.001	-	-	-	Left > Right
DI_Femurs	-	-	-6.476	293	<0.001	Right > Left	-	-	-5.262	296	<0.001	Right > Left

P - Two-tailed level of significance; Wilcoxon statistical test results were only presented for the variables where the paired t-test could not be used.

7.2.3 Indices: analysis according to sex of the individuals

Descriptive statistics of indices according to sex, as well as the statistical results for the mean differences between male and female individuals can be consulted in Table 89. Only two variables were not statistically significantly: DI of the right humerus ($t_{(588)}$=-0.524, p=0.600) and RI of the left femur ($t_{(576)}$=-1.967, p=0.050). In this later case the p-value was barely significant. Overall, men had higher indices values than females, with the exception of the platycnemic index (PI) in the tibiae.

Table 89 - Descriptive statistics of indices per sex sub-sample, and statistical test of mean comparison.

	Female					Male					Mann-Whitney test		Independent t-test		
	N	Minimum	Mean	Maximum	S.d.	N	Minimum	Mean	Maximum	S.d.	U	P	t	df	P
Humerus_left_RI	285	15,43	19,44	25,31	1,33	281	16,15	20,27	24,40	1,45	-	-	-7,046	564	<0.001
Humerus_right_RI	282	15,65	19,45	26,67	1,38	286	16,62	20,41	25,11	1,50	24847,0	<0.001	-	-	-
Radius_left_RI	262	14,54	18,11	22,46	1,38	278	14,58	18,69	22,77	1,52	-	-	-4,613	538	<0.001
Radius_right_RI	263	14,68	17,99	22,37	1,33	275	14,23	18,46	21,93	1,44	-	-	-3,968	536	<0.001
Ulna_left_RI	233	11,30	14,62	18,27	1,13	256	12,06	15,09	18,78	1,31	-	-	-4.125*	486.6	<0.001
Ulna_right_RI	238	10,67	14,69	18,60	1,08	257	11,72	15,19	18,60	1,33	23801,5	<0.001	-	-	-
Femur_left_RI	288	16,53	20,03	23,59	1,25	290	16,44	20,23	25,14	1,22	-	-	-1,967	576	0,050
Femur_right_RI	293	16,50	19,97	25,93	1,28	297	16,55	20,20	23,72	1,16	38114,5	0,007	-	-	-
Tibia_left_RI	288	15,94	20,48	25,49	1,43	287	16,14	20,82	24,84	1,46	35637,0	0,004	-	-	-
Tibia_right_RI	285	14,98	20,42	26,53	1,49	282	16,17	20,92	24,81	1,46	31967,0	0,001	-	-	-
Femur_left_PI	296	62,17	83,40	105,95	7,75	294	65,35	86,90	115,67	7,80	-	-	-5,539	588	<0.001
Femur_right_PI	300	61,97	85,77	116,08	7,99	298	68,49	88,51	120,14	8,01	-	-	-4.192	596	<0.001
Tibia_left_PI	301	58,07	74,62	93,86	5,63	296	58,91	73,03	90,45	6,00	-	-	3,338	595	0,001
Tibia_right_PI	299	60,94	75,53	101,84	5,92	297	55,85	73,46	91,58	6,30	-	-	4,211	594	<0.001
Humerus_left_DI	296	71,21	90,55	117,61	7,86	289	75,12	91,92	113,43	7,38	-	-	-2,181	583	0,030
Humerus_right_DI	297	72,08	93,94	116,89	7,92	293	75,43	94,27	116,71	7,30	-	-	-0,524	588	0,600
Radius_left_DI	294	54,38	74,03	97,08	6,36	292	61,54	76,98	98,33	6,60	-	-	-5,582	584	<0.001
Radius_right_DI	297	54,89	72,30	95,20	6,26	288	58,33	75,50	97,13	6,99	-	-	-5,802	583	<0.001
Ulna_left_DI	290	60,30	76,04	101,65	6,80	293	58,24	77,95	102,40	6,63	34366,0	<0.001	-	-	-
Ulna_right_DI	296	59,20	74,63	98,89	6,20	291	59,76	76,33	101,30	5,99	35631,5	<0.001	-	-	-
Femur_left_DI	299	80,50	105,05	133,28	8,85	295	75,83	107,12	132,70	9,11	-	-	-2,804	592	0,005
Femur_right_DI	297	55,85	73,46	91,58	6,30	299	77,58	108,89	135,13	9,02	-	-	-2,512	597	0,012

P - Two-tailed level of significance,* - equal variance not assumed according to Levene's Test for Equality of Variances; Mann Whitney statistical test results were only presented for the variables where the independent t-test could not be used.

The comparison of bilateral differences, within sexes, revealed a sex-related pattern as the males exhibited higher number of statistical significant bilateral asymmetries (Table 90), with the exception of the RI on the femurs (Z=-0.205, p=0.839), and the PI on the tibiae ($t_{(293)}$=-1.614, p=0.108). In females, the RI showed a clear absence of statistical difference between sides, with a marginal significant value being achieved for the RI_Radii (p=0.073). In both male and female sub-samples, with the exception of RI in the radii and the DI in the radii and ulnas, right side bones presented higher indices values.

Table 90 - Side pairwise comparison of indices per sex sub-samples.

	Males						Females					
	Wilcoxon test		Paired t-test			Side dominance	Wilcoxon test		Paired t-test			Side dominance
Index	Z	P	t	df	p		Z	P	t	df	p	
RI_Humeri	-	-	-2.433	274	0.016	Right > Left	-1.548	0.127	-	-	-	
RI_Radii	-	-	2.297	255	0.022	Left > Right	-	-	1.803	231	0.073	
RI_Ulnas	-	-	-2.469	235	0.014	Right > Left	-1.229	0.229	-	-	-	
RI_Femurs	-0.205	0.839	-	-	-		-	-	1.6343	280	0.103	
RI_Tibiae	-3.335	0.002	-	-	-	Right > Left	-0.404	0.688	-	-	-	
PI_Femurs	-	-	-4.808	292	<0.001	Right > Left	-	-	-7.87	293	<0.001	Right > Left
PI_Tibiae	-	-	-1.614	293	0.108		-	-	-3.893	296	<0.001	Right > Left
DI_Humeri	-	-	-6.39	286	<0.001	Right > Left	-	-	-8.749	291	<0.001	Right > Left
DI_Radii	-	-	4.861	282	<0.001	Left > Right	-	-	5.771	287	<0.001	Left > Right
DI_Ulnas	-	-	4.761	288	<0.001	Left > Right	-4.132	<0.001	-	-	-	Left > Right
DI_Femurs	-	-	-5.353	293	<0.001	Right > Left	-	-	-6.434	296	<0.001	Right > Left

P - Two-tailed level of significance; Wilcoxon statistical test results were only presented for the variables where the paired t-test could not be used.

7.2.4 Indices: analysis according to age at death of the individuals

The values of correlation among indices and age at death varied considerably between sub-samples analysed, that is, results found for the baseline sample, sex and collections sub-samples were different (Table 91). Robusticity indices correlations with age were all found to be positive, whilst for the remaining indices (PI and DI) almost all correlations were negative. That is, whilst robusticity values increased with age, the remaining indices' values decreased. However, because the correlation values found ranged from moderate to weak, or very weak, the interpretation of the results must be done with caution. Although a wide variety of results was presented, the majority of indices with a significant correlation in the total sample were also found in the Lisbon and females sub-samples (as illustrated by the light grey shaded areas in Table 91). The male sub-sample is the only one with more, overall, distinctive results. The correlations found were lesser in number.

Table 91 – Pearson's and Spearman's correlation results between indices and age per total sample, collections and sexes.

	Total sample			Collections						Sexes					
				Lisbon			Coimbra			Females			Males		
	n	r	p	n	r	p	n	r	p	n	r	p	n	r	p
Humerus_left_RI	566	0.095^{S}*	0.024	275	0.135*	0.025	291	0.112	0.057	285	0.150^{S}*	0.011	281	0.110^{S}	0.065
Humerus_right_ RI	568	0.077^{S}	0.067	280	0.139^{S}	0.020	288	0.079^{S}	0.184	282	0.178^{S}**	0.003	286	0.082^{S}	0.166
Radius_left_ RI	540	0.065^{S}	0.133	253	0.174**	0.006	287	0.026^{S}	0.666	262	0.128^{S}*	0.038	278	0.045^{S}	0.454
Radius_right_ RI	538	0.032	0.455	252	0.122	0.053	286	-0.030	0.615	263	0.060	0.332	275	0.065	0.280
Ulna_left_ RI	489	-0.056	0.220	213	0.079	0.250	276	-0.052	0.394	233	-0.053^{S}	0.420	256	-0.007^{S}	0.915
Ulna_right_ RI	495	-0.022^{S}	0.626	218	0.113^{S}	0.096	277	-0.041	0.493	238	0.040^{S}	0.538	257	-0.033^{S}	0.596
Femur_left_ RI	578	0.246**	<0.001	285	0.240^{S}**	<0.001	293	0.262**	<0.001	288	0.359**	<0.001	290	0.152**	0.010
Femur_right_ RI	590	0.223^{S}**	<0.001	294	0.194**	0.001	296	0.281^{S}**	<0.001	293	0.325^{S}**	<0.001	297	0.152^{S}**	0.009
Tibia_left_ RI	575	0.117**	0.005	283	0.024	0.683	292	0.292^{S}**	0.000	288	0.239^{S}**	<0.001	287	0.021^{S}	0.721
Tibia_right_RI	567	0.100^{S}*	0.017	278	0.011	0.856	289	0.272^{S}**	0.000	285	0.232^{S}**	<0.001	282	0.004^{S}	0.952
Femur_left_PI	590	-0.190^{S}**	<0.001	296	-0.275^{S}**	<0.001	294	-0176**	0.002	296	-0.199^{S}**	0.001	294	-0.106	0.069
Femur_right_PI	598	-0.146^{S}**	<0.001	301	-0.208**	<0.001	297	-0.150**	0.010	300	-0.121*	0.036	298	-0.099	0.089
Tibia_left_PI	597	-0.062	0.131	301	-0.056	0.331	296	-0.043	0.461	301	-0.098	0.089	296	-0.074	0.202
Tibia_right_PI	596	-0.096*	0.019	299	-0.112	0.054	297	-0.041	0.476	299	-0.164^{S}**	0.005	297	-0.078	0.179
Humerus_left_DI	585	-0.153**	0.001	291	-0.171^{S}**	0.003	294	-0.129*	0.027	296	-0.167**	0.004	289	-0.067	0.257
Humerus_right_DI	590	-0.131**	0.001	296	-0.197**	0.001	294	-0.025	0.668	297	-0.213**	<0.001	293	-0.022	0.706
Radius_left_DI	586	-0.028^{S}	0.504	289	-0.153**	0.009	297	-0.033	0.570	294	-0.078^{S}	0.182	292	0.106^{S}	0.072
Radius_right_DI	585	-0.031^{S}	0.448	289	-0.109^{S}	0.064	296	-0.170**	0.003	297	-0.045^{S}	0.439	288	0.056^{S}	0.346
Ulna_left_DI	583	-0.011^{S}	0.789	288	0.032^{S}	0.588	295	-0.015^{S}	0.800	290	0.031^{S}	0.594	293	0.025^{S}	0.670
Ulna_right_DI	587	-0.070^{S}	0.091	293	-0.051^{S}	0.380	294	-0.041^{S}	0.487	296	-0.024^{S}	0.675	291	-0.052^{S}	0.380
Femur_left_DI	594	-0.156**	<0.001	296	-0.189**	0.001	298	-0.120*	0.039	299	-0.166**	0.004	295	-0.111	0.058
Femur_right_DI	599	-0.143**	<0.001	301	-0.158**	0.006	298	-0.141*	0.015	300	-0.127*	0.028	299	-0.133*	0.022

P – Two-tailed significance level; * - Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed); S – identifies cases were the Spearman's correlation was used, when absent Pearson's correlation was employed.

7.2.5 Indices: occupational group comparisons

The ANCOVA test results (Table 92 to 94) showed a statistically significant difference between occupational groups and almost all indices analysed, when controlling for age. With the exceptions of the DI and RI of the radii and ulnas, both age and occupational groups influenced the indices values. As already referred to, the exception was DI and RI in the radii and ulnas (Table 93 and 94). In these cases, only occupational groups were found to be significant predictors of the indices in question. Age, contrary to all results found so far, was not. In these bones, age and occupations were only significant for the left radius RI (Table 94). The major observation to be made is that radii and ulnas appear to provide a contrary behaviour to that presented for humerus, femurs and tibiae. This fact is even more interesting as, with regard to the bilateral asymmetries found, radii and ulnas also displayed contrary results to the other long bones: they exhibited left side dominance, and not a right side one. Detailed descriptive statistics of the indices, per occupational group can be consulted in Table 64, Appendix_Indices.

Table 92 - ANCOVA test results: PI index.

Left_PI		df	F-value	Sig.	Right_PI		df	F-value	Sig.
Femur	Age	(1,582)	16.533	<0.001	Femur	Age	(1,590)	8.990	0.003
	Occupation	(6,582)	6.050	<0.001		Occupation	(6,590)	4.344	<0.001
Tibia	Age	(1,589)	4.113	0.043	Tibia	Age	(1,588)	9.331	0.002
	Occupation	(6,589)	3.045	0.006		Occupation	(6,588)	3.734	0.001

Table 93 - ANCOVA test results: DI index.

Left_DI		df	F-value	Sig.	Right_DI		df	F-value	Sig.
Humerus	Age	(1,577)	10.685	0.001	Humerus	Age	(1,582)	10.497	0.001
	Occupation	(6,577)	2.465	0.023		Occupation	(6,582)	1.700	0.119
Radius	Age	(1,578)	0.002	0.965	Radius	Age	(1,577)	0.244	0.621
	Occupation	(6,578)	6.054	<0.001		Occupation	(6,577)	9.431	<0.001
Ulna	Age	(1,575)	0.009	0.923	Ulna	Age	(1,579)	0.308	0.579
	Occupation	(6,575)	2.231	0.039		Occupation	(6,579)	2.901	0.009

Table 94 - ANCOVA test results: RI index.

Left_RI		df	F-value	Sig.	Right_RI		df	F-value	Sig.
Humerus	Age	(1,558)	14.345	<0.001	Humerus	Age	(1,560)	12.243	0.001
	Occupation	(6,558)	10.680	<0.001		Occupation	(6,560)	12.334	<0.001
Radius	Age	(1,532)	4.131	0.043	Radius	Age	(1,530)	2.608	0.107
	Occupation	(6,532)	3.953	0.001		Occupation	(6,530)	3.032	0.006
Ulna	Age	(1,481)	0.419	0.518	Ulna	Age	(1,487)	0.069	0.793
	Occupation	(6,481)	4.856	<0.001		Occupation	(6,487)	6.717	<0.001
Femur	Age	(1,570)	43.265	<0.001	Femur	Age	(1,582)	27.526	<0.001
	Occupation	(6,570)	2.716	0.013		Occupation	(6,582)	2.549	0.019
Tibia	Age	(1,567)	11.543	0.001	Tibia	Age	(1,559)	9.617	0.002
	Occupation	(6,567)	5.229	<0.001		Occupation	(6,559)	6.436	<0.001

Major differences between occupational groups differ accordingly to the index, and bone under examination, as illustrated in Figures 52 to 54. Post hoc pairwise comparison of the femurs PI indices revealed major mean dissimilarities between individuals working as farmers and servants, and the remaining occupational groups. For the tibiae, the only occupational group with significant different values, when compared to the other groups, was that composed of housewives. Female individuals exhibited higher PI values (Figure 52).

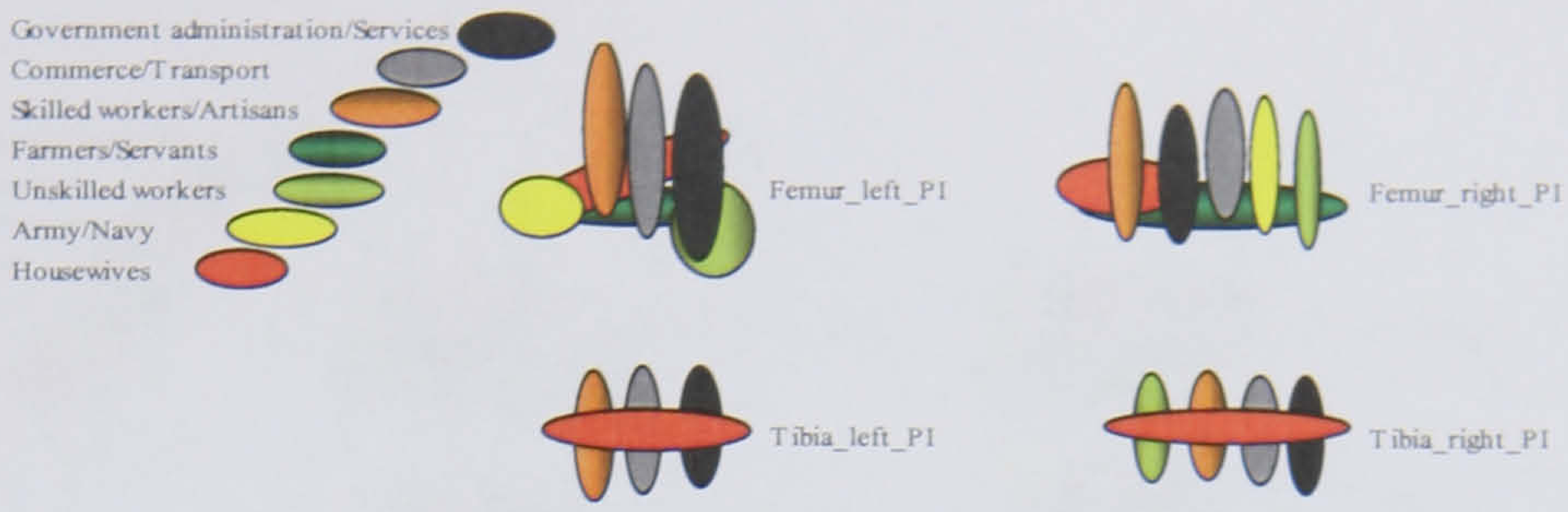


Figure 52 – PI index results of pairwise comparisons.

The pattern of occupational group differences for DI index showed that radii exhibited a higher number of divergences between groups, namely between farmers and servants, and housewives, in comparison to the remaining groups. Housewives consistently exhibited the lowest DI index, whilst unskilled workers and people working in the government and services accounted for the highest DI values. Other isolated interaction were found between groups, with individuals involved in commerce and transport, and the armed forces also presenting high DI values (Figure 53).

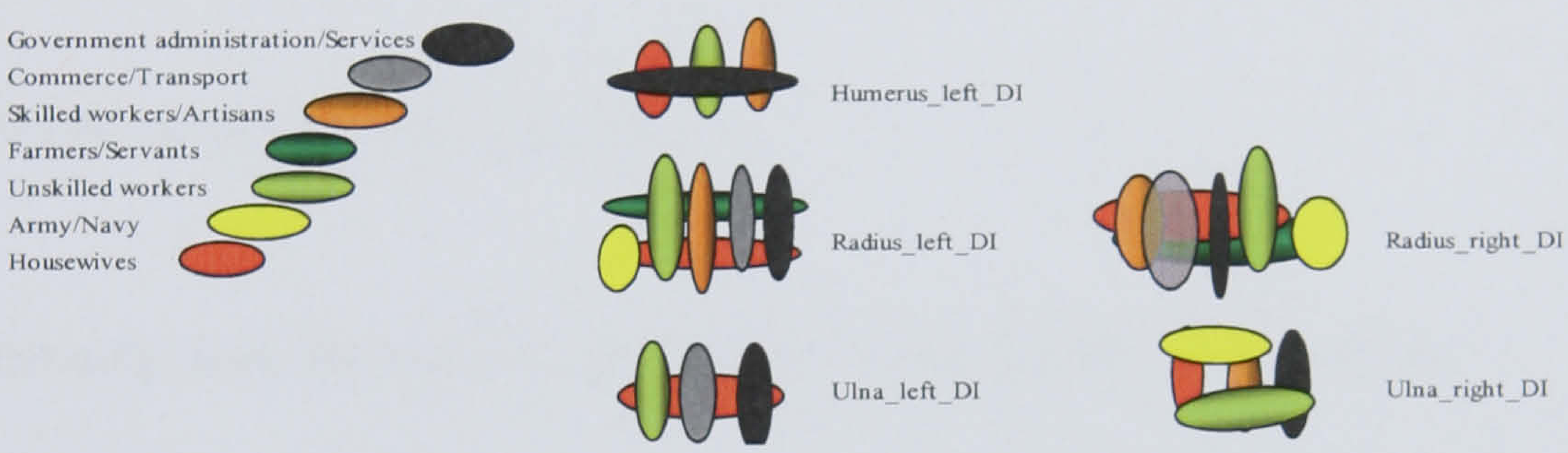


Figure 53 – DI index results of pairwise comparisons.

A greater number of occupational group differences were found for the RI indices. The major differences between occupational groups were found in the humerii, right ulna and tibiae. In general, right side bones exhibited higher significant interactions between groups; unskilled workers had one of the highest RI index value in all bones, whilst housewives had one of the lowest; between right and left side bones similar results were obtained, that is, the occupational groups showed statistically significant bilateral symmetry (Figure 54).

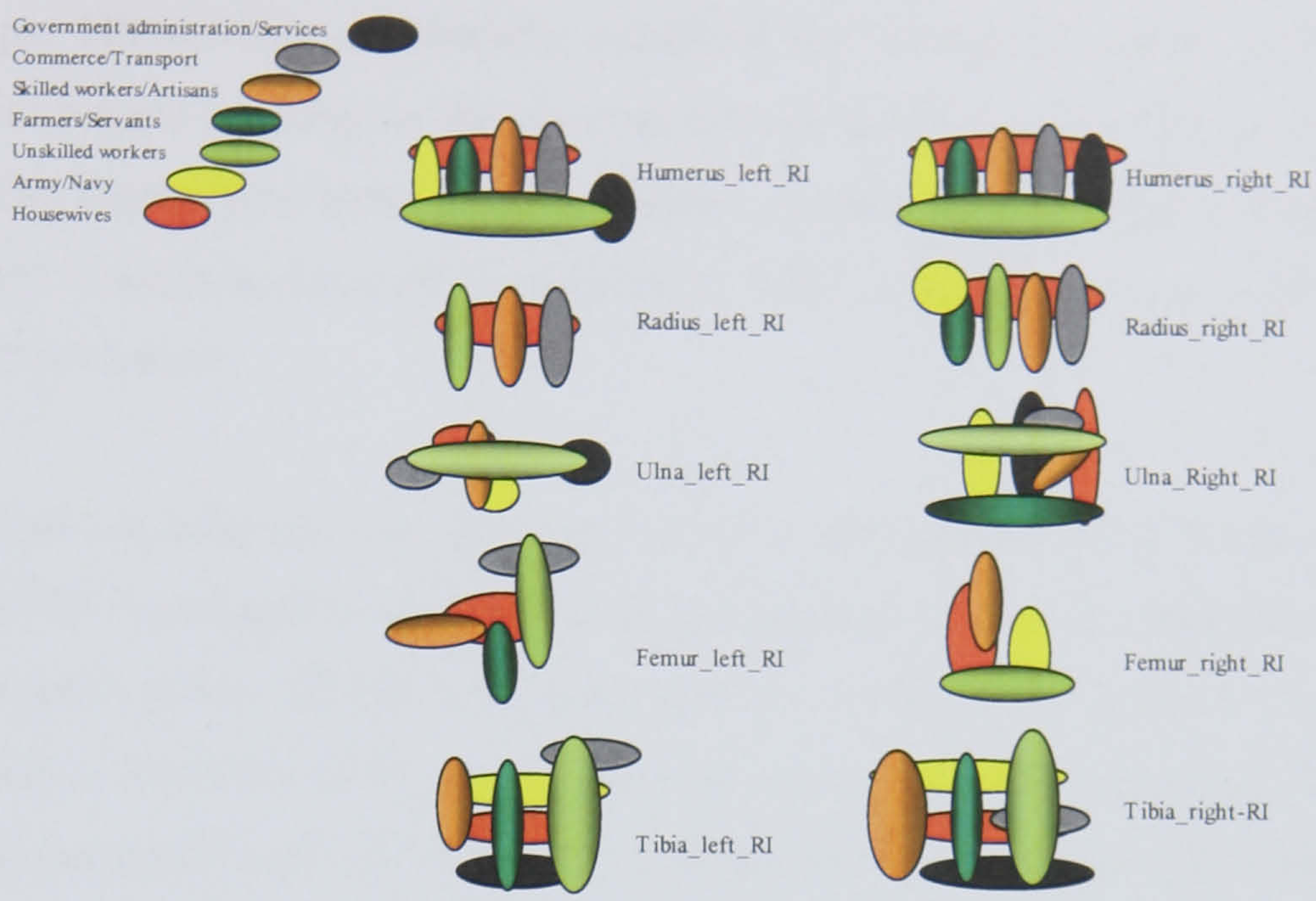


Figure 54 –RI index results of pairwise comparisons.

7.2.6 Summary and discussion of results of the postcranial indices

The current study has highlighted that: 1) ulnas and radii behaved differently than humeri, femurs and tibiae with regard to bilateral asymmetry. The latter consistently exhibited a right side dominance, whilst left radius and ulnas indices were higher than the right ones; 2) bilateral asymmetry was mostly male related, and men had higher index values when compared to females, with the exception of the platycnemic index (PI) in the tibiae; 3) Robusticity indices correlations with age were all found to be positive, whilst for the remaining indices (PI and DI) almost all correlations were negative; that is, whilst robusticity values increased with age, the remaining indices' values decreased; 4) with the exceptions of the DI and RI of the radii and ulnas, both age and occupational groups influenced the indices' values. Femurs' PI indices revealed major mean dissimilarities between individuals working as farmers and servants, and the remaining occupational groups. For the tibiae, the only occupational group with significant different values was that of housewives. DI index showed that radii exhibited a higher number of divergences between groups, namely between farmers and servants, and housewives in comparison to the remaining groups. Housewives consistently exhibited the lowest DI index, whilst unskilled workers and people working in the government and services accounted for the highest DI values. The Robusticity index had the highest number of occupational group interactions. Unskilled workers had one of the highest RI index value in all bones, whilst housewives exhibited the lowest.

A more detailed analysis on bilateral asymmetry within each occupational group disclosed that PI in femurs and DI continued to exhibit significant bilateral asymmetry throughout most of the occupational groups (Table 95); whilst the RI bilateral asymmetry, when significant, was limited to the bones of the upper limb, with exception of the tibia (p=0.026) in the commerce and transport category. In all, occupational groups that could have been perceived as particularly strenuous, exhibiting higher levels of significant asymmetry, showed similar behaviour to the remaining, supposedly less strenuous groups. A noteworthy exception was found for unskilled workers, in this case right side robusticity levels of the humerus and radius differed significantly from left side ones.

Table 95 – Bilateral asymmetry tests results per occupational groups.

		RI					PI		DI			
		Humerus	Radius	Ulna	Femur	Tibia	Femur	Tibia	Humerus	Radius	Ulna	Femur
Government administration/Services	t	-2,250	0,104	0,621	Z=-1.238	-1,791	-2.163	-1,680	-2,060	0,376	3,239	-2,331
	df	44	39	35		46	51	49	48	50	49	51
	P	**0,030**	0,917	0,538	0,117	0,080	**0,035**	0,099	**0,045**	0,708	**0,002**	**0,024**
Commerce/Transport	t	-0,556	1,815	-3,428	-1,238	-2,264	-2,336	-0,711	-2,110	0,193	Z=-3.113	-2,634
	df	77	71	57	75	78	80	82	80	76		80
	P	0,580	0,074	**0,001**	0,220	**0,026**	**0,022**	0,479	**0,038**	0,847	**0,001**	**0,010**
Skilled workers/Artisans	t	-0,658	1,795	-0,458	0,756	-1,676	-2,210	-0,407	-4,848	5,216	3,329	-2,529
	df	94	85	84	98	91	96	99	97	96	96	97
	P	0,512	0,076	0,648	0,452	0,097	**0,029**	0,685	**<0.001**	**<0.001**	**0,001**	**0,013**
Farmers/Servants	t	0,505	Z=-2.354	-0,954	0,667	0,161	Z=-2.846	-1,331	Z=-3.051	3,514	0,739	-2,891
	df	25		27	28	26		28		28	28	28
	P	0,618	**0,001**	0,348	0,510	0,873	**0,002**	0,194	0,001	0,002	0,466	0,007
Unskilled workers	t	-2,240	2,044	-1,472	0,670	-0,811	-2,992	-1,197	-3,620	1,742	0,891	Z=-2.346
	df	33	30	32	35	34	36	35	35	34	36	
	P	**0,032**	**0,050**	0,151	0,507	0,423	**0,005**	0,239	**0,001**	0,091	0,379	**0,011**
Army/Navy	t	-0,624	-1,553	-0,567	1,756	-0,864	Z=-1.217	-0,876	-1,813	1,218	-0,262	Z=-1.825
	df	20	20	16	22	22		22	20	20	22	
	P	0,540	0,136	0,578	0,093	0,397	0,115	0,391	0,085	0,237	0,796	**0,037**
Housewives	t	Z=-1.294	Z=-1.964	Z=-1.422	1,247	1,268	-7,287	Z=-3.435	-7,916	Z=-5.131	Z=-3.823	-6,004
	df				254	249	268		265			270
	P	0,096	**0,026**	0,078	0,214	0,206	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**<0.001**

P - Two tailed significance

Z - The cases where Z values were presented correspond to situations where there was a non-normal distribution, therefore the paired *t-test* was not used.

The lack of asymmetrical significance within occupational groups may be related to the practice of activities which demand similar use of both limbs. This assumption was already discussed by Knüsel and colleagues, in which they argued that the lack of asymmetrical significance could be related with the ambidextral used of limbs in activities (Blackburn and Knüsel, 2006; Knüsel, 2000; Rhodes and Knüsel, 2005). Blackburn and Knüsel (2006) also argued that asymmetry may be left-sided, and not right-sided, not necessarily because individuals were left-handed or were using left-side limb more, but simply because their activity may require the use of both hands, reflecting a bi-manual activity and not a uni-manual activity (Blackburn and Knüsel, 2006; Rhodes and Knüsel, 2005). However, if one assumes that hypertrophy on one side limb equals its overuse, why not assume that for both left and right side asymmetrical significance? The discussion on the impact of bi/uni-lateral activity needs further testing, so that the assumption argued by Knüsel and colleagues can be proved correct, or seen as another contribution to the overall variety of human skeletal behavioural response. In the current research it was impossible to test the handedness of the individuals under analysis, however a selected group of individuals with known occupations was used to test the hypothesis of bi/uni-lateral activities showed similar results of bilateral asymmetry. This will also be useful to see if bilateral asymmetry found in the overall category, would differ from the one found in more specific professions encountered in the occupational group.

This hypothesis was tested in a group of 48 individuals, consisting of shoemakers (12/48), carpenters (15/48) and bricklayers (8/48) all from the occupational group labelled skilled workers and artisans, with the remaining individuals being civil servants (13/48) (grouped in the administration and services occupational group). The results showed that, when specific occupations were analysed, bilateral asymmetry significance is practically inexistent. With the exception of femur PI for the civil servants, the DI in the humerus and ulna of the shoemakers, and humerus and radius DI for the carpenters, the remaining cases showed no bilateral asymmetry (Table 96). If these results are compared to the ones obtained for the overall occupational group - skilled workers and artisans - the observation is practically the same: bilateral asymmetry is limited to DI, and in ulnas and radius left side DI is significantly different from right side, whilst in humerus there is right-side dominance. The results obtained point out that, with the exceptions of the significant values achieved, right and left side limbs/bones were engaged in the activities performed, favouring a bi-manual approach to the results. However, the left side dominance encountered for ulnas as radius, may not necessarily be the result of a bi-manual activity, and one should look for alternative justifications and testing before assuming that in this particular case ulna and radius left handedness is the result of bi-manual activity.

Table 96 – Bilateral asymmetry test results for specific occupational groups.

		RI					PI		DI			
		Humerus	Radius	Ulna	Femur	Tibia	Femur	Tibia	Humerus	Radius	Ulna	Femur
Civil servant	t	-0,742	1,174	-0,653	0,358	-0,227	-2,484	-0,790	0,132	0,781	2,093	-1,370
	df	12	11	11	11	9	12	10	12	11	12	12
	P	0,472	0,265	0,527	0,727	0,825	0,029	0,448	0,897	0,451	0,058	0,196
Shoemaker	t	-0,714	0,374	0,284	-1,355	0,155	-0,097	-0,559	-3,451	0,144	2,208	-1,890
	df	11	11	8	11	10	9	11	11	11	11	10
	P	0,490	0,715	0,783	0,203	0,880	0,925	0,588	0,005	0,888	0,049	0,088
Carpenter	t	-0,203	1,168	-0,661	1,307	-0,767	-0,462	-0,590	-2,516	2,826	-0,231	-1,419
	df	14	12	13	14	13	14	14	14	14	14	14
	P	0,842	0,266	0,520	0,212	0,457	0,651	0,564	0,025	0,013	0,820	0,178
Bricklayer (mason)	t	0,895	2,169	0,656	1,402	-0,132	-1,425	-0,712	-0,675	2,157	0,472	-1,615
	df	6	4	2	7	5	7	7	7	7	7	7
	P	0,405	0,096	0,579	0,204	0,900	0,197	0,500	0,521	0,068	0,651	0,150

P - Two-tailed significance

Many bioarchaeological studies have focussed on sex-related significant index results to assess sexual division of labour in past human populations (Bridges, 1989; Ledger *et al.*, 2000; Sládek *et al.*, 2007: amongst many others). On the current sample, with the exception of the PI in the tibia, the overall results revealed that women had in general lower values of indices, when compared to men. Direct comparison between male and females' values are discouraged, unless one is trying to determine the degree of sexual dimorphism of a particular population. To argue that females' postcranial indices are of lower values because they were involved in less mechanically demanding activities, and to use these male-female differences to establish a sexual work divide within a sample, is to bias the results found. Activity related changes in the skeleton should always be tested within a particular sex. In the current sample, the results presented in this Chapter (section 7.2.5) revealed that the housewives category consistently exhibited the lower mean values between occupational groups. This fact was one of the major causes for the significant results found between occupational groups. To test the hypothesis that in the absence of the housewives category, the occupational groups' contribution to the outcome of the indices would be different, a second set of analyses were performed. In this analysis the housewives category was excluded. The results obtained show that without that group, PI in tibias, DI in the ulnas, RI in the radii and femurs are no long significant, that is, occupational groups no longer differ between themselves with regard to the index under analysis (Tables 97 to 99). In the remaining cases, the significances found are maintained: in femurs PI, and radii and humerus DI farmers and servants exhibit the lowest values of indices; in the RI, unskilled workers are the occupation group with highest mean values.

Table 97 – ANCOVA test results: PI index (exclusion of occupational group Housewives).

Left_PI		df	F-value	Sig.	Right_PI		df	F-value	Sig.
Femur	Age	(1,312)	7,421	0,007	Femur	Age	(1,318)	4,850	0,028
	Occupation	(5,312)	3,999	0,002		Occupation	(5,318)	3,134	0,009
Tibia	Age	(1,316)	1,438	0,231	Tibia	Age	(1,317)	1,821	0,178
	Occupation	(5,316)	0,740	0,594		Occupation	(5,317)	0,491	0,783

Table 98 - ANCOVA test results: DI index (exclusion of occupational group Housewives).

Left_DI		df	F-value	Sig.	Right_DI		df	F-value	Sig.
Humerus	Age	(1,308)	5,990	0,015	Humerus	Age	(1,312)	2,471	0,117
	Occupation	(5,308)	2,655	0,023		Occupation	(5,312)	1,759	0,121
Radius	Age	(1,312)	2,512	0,114	Radius	Age	(1,308)	0,292	0,589
	Occupation	(5,312)	2,275	0,047		Occupation	(5,308)	5,382	<0.001
Ulna	Age	(1,312)	0,023	0,880	Ulna	Age	(1,311)	0,203	0,653
	Occupation	(5,312)	0,829	0,530		Occupation	(5,311)	1,958	0,085

Table 99 - ANCOVA test results: DI index (exclusion of occupational group Housewives).

Left_RI		df	F-value	Sig.	Right_RI		df	F-value	Sig.
Humerus	Age	(1,299)	6.346	0.012	Humerus	Age	(1,304)	6.224	0.109
	Occupation	(5,599)	3.174	0.008		Occupation	(5,304)	2.793	0.017
Radius	Age	(1,294)	0.781	0.378	Radius	Age	(1,291)	1.787	0.182
	Occupation	(5,294)	0.721	0.608		Occupation	(5,291)	1.286	0.270
Ulna	Age	(1,271)	0.130	0.719	Ulna	Age	(1,274)	0.060	0.806
	Occupation	(5,271)	2.681	0.022		Occupation	(5,274)	4.516	0.001
Femur	Age	(1,309)	12.561	<0.001	Femur	Age	(1,317)	9.093	0.003
	Occupation	(5,309)	1.450	0.260		Occupation	(5,317)	1.698	0.135
Tibia	Age	(1,307)	0.648	0.422	Tibia	Age	(1,302)	0.166	0.684
	Occupation	(5,307)	3.392	0.005		Occupation	(5,302)	3.184	0.008

In order to ascertain whether there is any relationship between postcranial indices and the level of degenerative changes observed, several correlation tests were performed. Postcranial indices were tested for the SumDBC and SumMSM limb variables. The Spearman statistical tests revealed a series of correlations (see Appendix_Indices; section 1.5). Therefore one could conclude that there was an association between degenerative bony changes at the joints and entheses, and with the shape and morphology of the long bones. However, the values of correlation were moderate to very low; therefore, the association found is of low significance. Ultimately, and although a correlation was found, this may not necessarily reflect an occupational or activity issue. Therefore, this assumption requires further assessment, as well as additional testing and determination of other correlations between shape, morphology, degenerative bony changes, along with other factors such as sex, diet or ethnicity.

In summary, the results obtained and interpretations proved that if the objective is to assess sex related differences between indices, such an approach should be carefully considered since most indices will reflect populational sexual dimorphism and not necessarily activity or occupational related differences. If one was to use postcranial indices as a measure of activity, one should account for the influence of the sex variable as an index confounding variable. Only whilst controlling for sex, would it be reasonable to test occupational related hypotheses. However, to do so one would also need to evaluate male and female differences within a "specific" dimension of activity related tasks, in order to test whether similar tasks performed for males and females had similar results. If differential results were observed, this scenario should allow for the consideration of other variables. This will also need to further address the specific "performative demands" of those same occupations. This is particularly true in order to infer or address bi/uni-lateral activity influences upon those indices. Studies should also consider other confounding variables such as diet, differential age influences, and genetic factors (as discussed in chapter 3). In conclusion, in the current research, to draw specific conclusions about occupation and indices used would be unreliable and could be open to criticism.

7.3 Analysis of Other Markers of Occupational Stress - O.MOS

In the following section concerns a brief summary result on the presence of trauma, periostitis, Schmorl's nodes (SN) and spondylolysis (identified as *Other Markers of Occupational Stress* – O.MOS). The analysis tested associations between any of theses MOS and total sample, collection, sexes and occupational groups' sub-samples, as well as age at death. Due to the small amount of cases, individuals were grouped into 5 age-at-death groups: 20 – 39, 40 – 49, 50 – 59, 60 – 69, and 70 ≥. A brief conclusion will be presented in the end.

7.3.1 O.MOS: total sample and collection sub-sample

The frequency of lesions according to collection can be consulted in Table 100. Overall, periostitis (20.9%) and SN (50.33%) had the highest percental values. Cases of dislocation, and spondylolysis were the least frequent, circa 2%. In all, the Lisbon collection (LLSC) had higher frequency of lesions that the Coimbra collection (CISC).

Table 100 – Frequency table of O.MOS per skeletal collection sub-sample and total sample.

		Trauma		Dislocation		Periostitis		Spondylolysis		Schmorl´s nodes	
		Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present
Lisbon	N	279	25	298	6	222	82	297	5	136	166
(n=304)	% within Collection	91,78	8,22	98,03	1,97	73,03	26,97	98,34	1,66	45,03	54,97
	% of Total	46,27	4,15	49,42	1,00	36,82	13,60	49,42	0,83	22,67	27,67
Coimbra	N	283	16	290	9	255	44	290	9	162	136
(n=299)	% within Collection	94,65	5,35	96,99	3,01	85,28	14,72	96,99	3,01	54,36	45,64
	% of Total	46,93	2,65	48,09	1,49	42,29	7,30	48,25	1,50	27,00	22,67
Total	N	562	41	588	15	477	126	587	14	298	302
(N=603)	% of Total	93,20	6,80	97,51	2,49	79,10	20,90	97,67	2,33	49,67	50,33

According to the Chi-Square statistics, significant association between collections and O.MOS were found for periostitis ($p<0.001$) and SN ($p=0.022$), however both cases showed low values of Cramer's *V*, revealing a weak association (Table 101). In both these cases, the probability of lesions was higher in the LLSC, for instance: the probability of periostitis in the LLSC was of 26.97%, in comparison with 14.72% in the CISC. In the remaining O.MOS, although no statistical association was found, individuals of the LLSC had a higher probability of trauma, whilst individuals of the CISC were more likely to exhibit dislocations and spondylolysis.

Collection	$\chi^2_{(df=1)}$	P*	Cramer's *V*
Trauma	1,963	0,196	0,057
Dislocation	0,667	0,445	0,033
Periostitis	13,703	**<0.001**	**0,151**
Spondylolysis	1,211	0,294	0,045
Schmorl's nodes	5,222	**0,022**	**0,093**

P*- two-tailed significance.

Table 101 – Chi-square statistics: association between O.MOS and collection sub-sample.

7.3.2 O.MOS: sex sub-sample

When the sex sub-sample is taken into account, with the exception of dislocations, male individuals had the highest frequency of cases (Table 102). Statistically significant associations between sex and O.MOS were fund for spondylolysis (p=0.033) and SN (p<0.001) (Table 103). The Cramer's *V* identified as weak association in the cases of dislocations, but moderate ones for SN. In both cases males had higher probability of developing these types of lesions.

Table 102 - Frequency table of O.MOS per sex sub-sample and total sample.

		Trauma		Dislocation		Periostitis		Spondylolysis		Schmorl's nodes	
		Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present
Female	N	285	18	294	9	241	62	298	3	185	115
(n=303)	% within sex	94,06	5,94	97,03	2,97	79,54	20,46	99,00	1,00	61,67	38,33
	% of Total	47,26	2,99	48,76	1,49	39,97	10,28	49,58	0,50	30,83	19,17
Male	N	277	23	294	6	236	64	289	11	113	187
(n=300)	% within sex	92,33	7,67	98,00	2,00	78,67	21,33	96,33	3,67	37,67	62,33
	% of Total	45,94	3,81	48,76	1,00	39,14	10,61	48,09	1,83	18,83	31,17
Total	N	562	41	588	15	477	126	587	14	298	302
(N=603)	% of Total	93,20	6,80	97,51	2,49	79,10	20,90	97,67	2,33	49,67	50,33

Table 103 - Chi-square statistics: association between O.MOS and sex sub-sample.

Sex	$\chi^2_{(df=1)}$	P*	Cramer's *V*
Trauma	0,709	0,423	0,034
Dislocation	0,585	0,603	0,031
Periostitis	0,069	0,841	0,011
Spondylolysis	4,708	**0,033**	**0,089**
Schmorl's nodes	34,562	**<0.001**	**0,240**

P*- two-tailed significance.

7.3.3 O.MOS: age-at-death associations

The association between age-at-death groups and O.MOS varied, whilst the probability of trauma, dislocation and periostitis was higher in older groups, spondylolysis and SN presence was higher in younger age-at-death groups (Table 104). For SN the probability of individuals possessing this type of lesion was very similar throughout all age groups, roughly 50% in all groups. The Chi-square statistical test revealed a statistically significant association between age-at-death groups, trauma (p=0.017), dislocation (p=0.011) and periostitis (0.001) (Table 105). However, the strength of the association was weak.

Table 104- Frequency table of O.MOS per age-at-death groups.

Age Group		Trauma		Dislocation		Periostitis			Spondylolysis			Schmorl's nodes	
		Absent	Present	Absent	Present	Absent	Present		Absent	Present		Absent	Present
20 - 39 y.o.	N	166	6	171	1	156	16	20 - 39 y.o.	169	3	20 - 39 y.o.	85	[illegible]
(n=172)	% within age group	96,51	3,49	99,42	0,58	90,70	9,30	(n=172)	98,26	1,74	(n=172)	49,42	50,58
	% of Total	27,53	1,00	28,36	0,17	25,87	2,65		28,12	0.50		14,17	14,50
40 - 49 y.o.	N	84	5	88	1	66	23	40 - 49 y.o.	87	2	40 - 49 y.o.	45	44
(n=89)	% within age group	94,38	5,62	98,88	1,12	74,16	25,84	(n=89)	97,75	2,25	(n=89)	50,56	49,44
	% of Total	13,93	0,83	14,59	0,17	10,95	3,81		14,48	0,33		7,50	7,33
50 - 59 y.o.	N	108	6	111	3	84	30	50 - 59 y.o.	108	5	50 - 59 y.o.	50	63
(n=114)	% within age group	94,74	5,26	97,37	2,63	73,68	26,32	(n=113)	95,58	4,42	(n=113)	44,25	55,75
	% of Total	17,91	1,00	18,41	0,50	13,93	4,98		17,97	0,83		8,33	10,50
60 - 69 y.o.	N	83	6	88	1	66	23	60 - 69 y.o.	86	3	60 - 69 y.o.	43	46
(n=89)	% within age group	93,26	6,74	98,88	1,12	74,16	25,84	(n=89)	96,63	3,37	(n=89)	48,31	51,69
	% of Total	13,76	1,00	14,59	0,17	10,95	3,81		14,31	0,50		7,17	7,67
70+ y.o.	N	121	18	130	9	105	34	70+ y.o.	137	1	70+ y.o.	75	62
(n=139)	% within age group	87,05	12,95	93,53	6,47	75,54	24,46	(n=138)	99,28	0,72	(n=137)	54,74	45,26
	% of Total	20,07	2,99	21,56	1,49	17,41	5,64		22,80	0,17		12,50	10,33

Spondylolysis and SN have different sample values because some of the skeletons missed part, or the whole, vertabral column.

Table 105 - Chi-square statistics: association between O.MOS and age-at-death groups.

Age-at-death groups	$\chi^2_{(df=4)}$	P*	Cramer's V
Trauma	**11,893**	**0,017**	**0,140**
Dislocation	**F**	**0,011**	**0,147**
Periostitis	**19,716**	**0,001**	**0,181**
Spondylolysis	F	0,354	0,086
Schmorl's nodes	2,838	0,587	0,069

P*- two-tailed significance; F - Fisher's Exact test.

Further testing on age-at-death and O.MOS, using Mann-Whitney statistical test, revealed the presence of a significant difference between the mean age at death of individuals with, and without fractures (U=8009, p=0.001; two-tailed significance), dislocation (U=1626, p=0.002; two-tailed significance) and periostitis (U=23748, p<0.001; two-tailed significance). No statistically significant difference was found between the mean age at death of individuals with, and without spondylolysis (U=4105.5, p=0.997; two-tailed significance) and SN (U=44197.5, p=0.708; two-tailed significance). In general, and as observable in Table 106, the average age of individuals with the lesion was higher than individuals without, although in the case of spondylolysis and SN both mean values are almost identical.

Table 106 – Descriptive statistics of age-at-death according to O.MOS.

Trauma	N	Minimum	Mean	Maximum	Std. Deviation
Absent	562	20	52.21	98	18.74
Present	41	20	62.15	89	18.70
Dislocation					
Absent	588	20	52.49	98	18.79
Present	15	38	68.33	91	16.69
Periostitis					
Absent	477	20	51.46	95	19.34
Present	126	23	58.27	98	16.01
Spondylolysis					
Absent	587	20	52.84	98	18.98
Present	14	27	52.57	80	14.92
SN					
Absent	298	20	53.19	98	20.08
Present	302	20	52.42	93	17.65

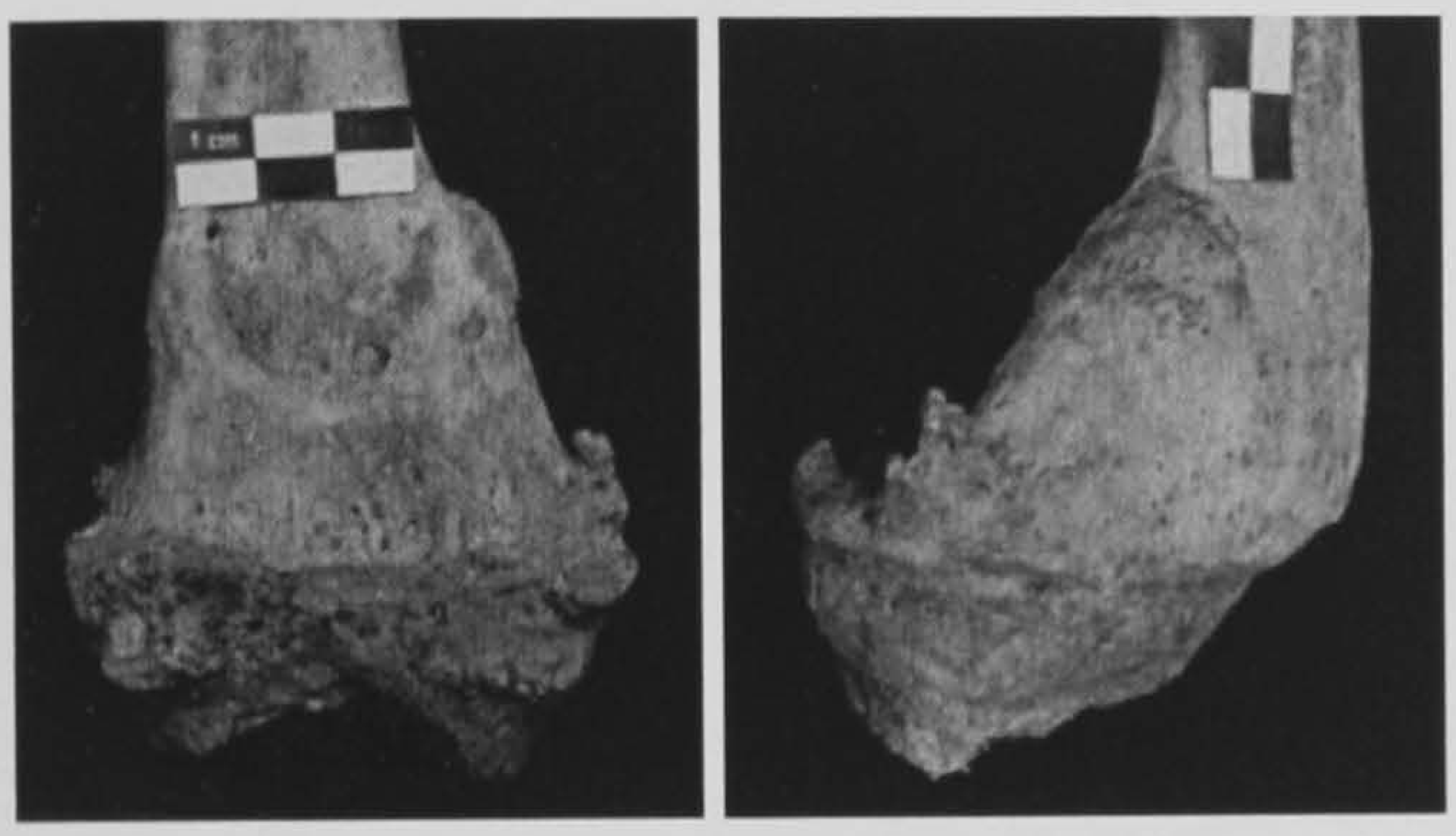
The fact that some O.MOS, such as trauma, were associated with older individuals does not necessarily mean that this pathology is age related. The majority of the fractures were very well healed (34/41), indicating that they occurred several years prior to the individual's death. It is therefore impossible to be conclusive regarding the occurrence of the lesions, and the age of the individual at the time of death.

Additional data on the trauma observed in this sample revealed that the most affected bones were the tibiae, femurs and radius (Table 107). The distal third of the shaft was the most frequently affected site (53.7% - 22/41) followed by the proximal extremity (29.3% - 12/41) and finally the middle portion of the shaft (14.6% - 6/41). The majority of the traumas were recorded on the left side (63% - 26/41; right, 37% - 15/41).

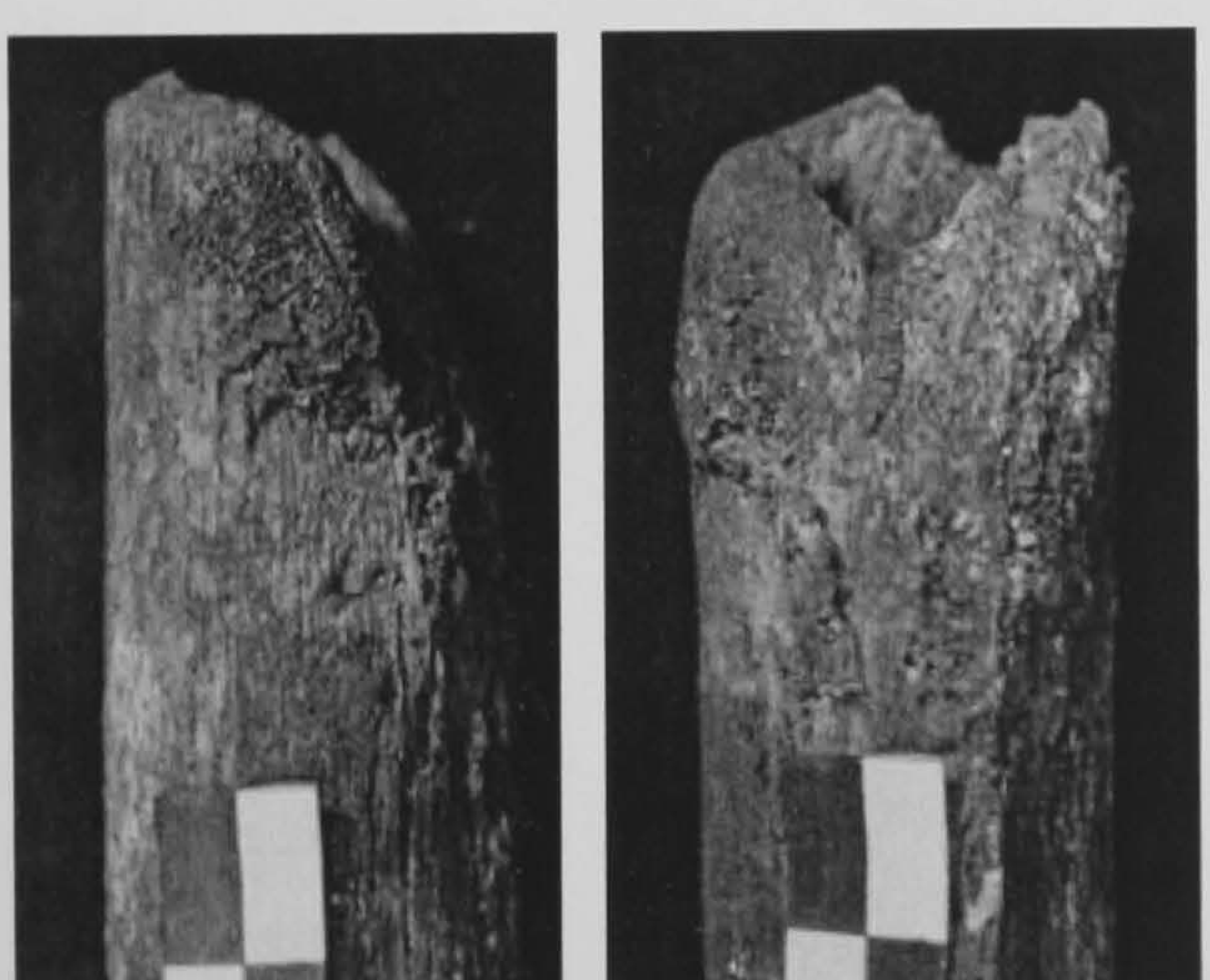
Table 107 – Frequency of fractures according to type of bone affected and location of the fracture.

Upper limb	humerus		radius		ulna		clavicle		humerus & radius	
Site of fracture	n	%	n	%	n	%	n	%	n	%
Proximal	3	7,3	0	0	1	2,4	0	0	0	0
Distal	0	0	6	14,6	4	9,8	1	2,4	2	4,9
Middle	0	0	1	2,4	0	0	3	7,3	0	0
Total (21/41)	3	7,3	7	17,1	5	12,2	4	9,8	2	4,9
Lower limb	femur		tibia		tibia & fibula		femur & tibia		fibula	
Site of fracture	n	%	n	%	n	%	n	%	n	%
Proximal	8	19,5	0	0	0	0	0	0	0	0
Distal	0	0	5	12,2	3	7,3	0	0	1	2,4
Middle	1	2,4	0	0	1	2,4	0	0	0	0
Distal end of femur & proximal end of tibia	0	0	0	0	0	0	1	2,4	0	0
Total (20/41)	9	22	5	12,2	4	9,8	1	2,4	1	2,4

In general, the lesions appear to be isolated episodes, not affecting adjacent bones nor leading to degeneration of adjoining joints, or infection. The fact that there are no cases of severe bone shortening, or misalignments, particularly where both fibula and tibia were fractured may be indicative of the presence of medical treatment. There are some exceptions to this general picture, as exemplified by the cases where the healing processes was either interrupted, or anatomically incorrect, as illustrated in figure 55. In some cases the healing process of the fractured bones was progressing at the time of death of the individuals (Figure 55 -b). Another example shows incorrect bone alignment with a complete fusion of the knee joint (Figure 55 -a). There were also recorded cases of a clear medical treatment, due to the presence of surgical pins that supported/immobilized the joint during its healing process (Figure 55 – c).



a) Complete fusion of the knee



b) Diaphyseal of femur with evidence of bone remodelling

c) Femur with medical pin

Figure 55 – Examples of types of fractures observed.

7.3.4 O.MOS: occupational group associations

The interpretation of O.MOS distributed per occupational groups requires care, due to the uneven number of individuals per group (Table 108). The chi-square and Fisher's Exact test only identified two statistical significant associations: spondylolysis (p=0.021) and SN (p<0.001). However, if the Housewives occupational group was excluded from the analysis, the presence of significant results disappeared (Table 109). These results reinforce the need for cautionary interpretation of the association between occupational group and O.MOS; in effect, one could safely conclude that such association is non- existent. The probability of having a particular O.MOS varied immensely between groups (see % within occupation: Table 108). However, one can observe that the probability of trauma was higher in the groups of people working in commerce and transport, and as artisans and skilled workers; dislocations would probably affect more artisans and skilled workers, as well as farmers and servants; and spondylolysis would be more prone in farmers, servants and unskilled workers. On the other hand, the probability of periostitis and SN occurring was similar throughout all occupational groups, with the exception of housewives in SN. The probability of "housewives" having SN was of 37.59%, compared to the overall 50% or more in the remaining occupations.

Table 108 – Frequency of table of O.MOS per occupational groups.

Occupational group		Trauma		Dislocation		Periostitis			Spondylolysis			Schmorl's	
		Absent	Present	Absent	Present	Absent	Present		Absent	Present		Absent	Present
Government administration/Services	Count	50	3	52	1	43	10	(n=52)	51	1	(n=52)	18	34
(n=52)	% within occupation	94.34	5.66	98.11	1.89	81.13	18.87		98.08	1.92		34.62	65.38
	% of Total	8.29	0.50	8.62	0.17	7.13	1.66		8.49	0.17		3.00	5.67
Commerce/Transport	Count	76	8	82	2	61	23	(n=84)	82	2	(n=84)	31	53
(n=84)	% within occupation	90.48	9.52	97.62	2.38	72.62	27.38		97.62	2.38		36.90	63.10
	% of Total	12.60	1.33	13.60	0.33	10.12	3.81		13.64	0.33		5.17	8.83
Skilled workers/Artisans	Count	92	9	98	3	84	17	(n=101)	98	3	(n=101)	38	63
(n=101)	% within occupation	91.09	8.91	97.03	2.97	83.17	16.83		97.03	2.97		37.62	62.38
	% of Total	15.26	1.49	16.25	0.50	13.93	2.82		16.31	0.50		6.33	10.50
Farmers/Servants	Count	27	2	28	1	24	5	(n=29)	27	2	(n=29)	14	15
(n=29)	% within occupation	93.10	6.90	96.55	3.45	82.76	17.24		93.10	6.90		48.28	51.72
	% of Total	4.48	0.33	4.64	0.17	3.98	0.83		4.49	0.33		2.33	2.50
Unskilled workers	Count	35	2	37	0	28	9	(n=37)	34	3	(n=37)	15	22
(n=37)	% within occupation	94.59	5.41	100	0	75.68	24.32		91.89	8.11		40.54	59.46
	% of Total	5.80	0.33	6.14	0	4.64	1.49		5.66	0.50		2.50	3.67
Army/Navy	Count	23	0	23	0	20	3	(n=23)	22	1	(n=23)	11	12
(n=23)	% within occupation	100	0	100	0	86.96	13.04		95.65	4.35		47.83	52.17
	% of Total	3.81	0	3.81	0	3.32	0.50		3.66	0.17		1.83	2.00
Housewives	Count	259	17	268	8	217	59	(n=275)	273	2	(n=274)	171	103
(n=274)	% within occupation	93.84	6.16	97.10	2.90	78.62	21.38		99.27	0.73		62.41	37.59
	% of Total	42.95	2.82	44.44	1.33	35.99	9.78		45.42	0.33		28.50	17.17

Spondylolysis and SN have different sample values because some of the skeletons missed part of the whole vertebral column. Bold percentages refer to groups where the probability of lesions were higher

Table 109 - Chi-square statistics: association between O.MOS and occupational groups

Occupational Group	$\chi^2_{(df=4)}$	P*	Cramer's V	Without Housewives $\chi^2_{(df=4)}$	Without Housewives P*
Trauma	3,773	0,714	0,079	F	0.682
Dislocation	F	0,982	0,058	F	0.907
Periostitis	4,672	0,590	0,088	4.668	0.461
Spondylolysis	**F**	**0,021**	**0,140**	F	0.572
Schmorl's nodes	**35,126**	**<0.001**	**0,242**	2.495	0.781

P* - two-tailed significance; F - Fisher's Exact test.

7.3.5 Summary and discussion of the results of O.MOS

The analysis of O.MOS proved that periostitis and Schmorl's nodes (SN) were the most frequent lesions recorded, followed by trauma, including dislocations and spondylolysis. The former two were also the only lesions statistically associated with the collections' sub-samples, whilst SN and spondylolysis were statistically significant in the sex sub-sample, and more probable in male individuals. When age-at-death associations were tested, trauma, dislocation and periostitis were found to be statistically significant. In these cases the average age-at-death of the individuals with the lesions was significantly higher than for spondylolysis and SN; also both in spondylolysis and SN the average of the age-at-death of individuals with and without the lesions was similar. The analysis of O.MOS, per occupational group, revealed that the significant association found in spondylolysis and SN was biased by the grouping of females as housewives. If this group was excluded from the analysis, no significance is achieved. Despite the non significance of these results, one can conclude that the probability of developing periostitis or SN is similar in all occupational groups, whilst trauma was more probable in people working in commerce, transport and skilled workers/artisans; dislocations were more probable in skilled workers/artisans and farmers and servants. Finally, farmers, servants and unskilled workers were more prone to develop spondylolysis.

At this point a more reliable approach to the data would be simply to summarise the results. This is particularly so since the majority of the MOS addressed in this research were discussed within a framework of "re-evaluation". To state that, for instance, trauma was more probable in people working in commerce, transport and skilled workers/artisans, because within these occupational groups the activities they were performing increased the risk of trauma, seems extremely simplistic. Maybe there is an underlying "activity-related" reason for the probability of trauma and dislocations being more probable in skilled workers/artisans and farmers and servants. This could also account for the fact that farmers, servants and unskilled workers were more prone to develop spondylolysis. To explore such an assumption more thoroughly, one would have to be far more scrupulous with regard to what specific activities were being performed within each group, and conduct a similar research in a clinical context in order to ascertain whether such events could originate the type of O.MOS observed. As stated by Jurmain (1999) "the *only* way to achieve any degree of precision relating to aetiology of such conditions is from well-documented clinical contexts" (219). This observation must also be applicable to the other MOS discussed in this section.

Chapter 8: Gender and palaeopathology: an impossible relationship?

As stated at the beginning of this thesis, the primary aim of the research was to portray gender differences in Portuguese populations from the late 19th and early 20th century. This portrayal of gender was to be based on a paleopathological perspective, focussing on palaeopathological conditions referred to as *markers of occupational stress* (MOS). The assumption was that on the one hand gender differences would create specific sexual division of labour within the population. On the other, this division would be reflected in the occupations taken, and that these could ultimately be inferred through the analysis of skeletal markers of activity. The indicators selected were degenerative bony changes (DBC), musculoskeletal stress markers (MSM), and post-cranial indices based on the external diaphyseal measurements of the long bones. Trauma, Schmorl's nodes, spondylolysis and tibiae periostitis were other osteological markers considered to interpret activity.

The human skeletons used for this doctoral research were selected from the Coimbra Identified Skeletal Collection (CISC) and the Luis Lopes Skeletal Collection of the Museu Bocage (LLSC). The skeletal samples selected shared a common historical, cultural and socioeconomic context although one of the collection's provenance was rural and the other urban. The CISC collection was rural as it included many individuals of the wider rural region, whereas the most of the individuals from the LLSC had an urban background (see chapter 5 for details). The LLSC collection, therefore, included a higher number of individuals working in activities such as commerce, transport, bank and civil services. Nevertheless, the differences between rural and urban in the late 19th and early 20th centuries are not as clear cut as may have been presumed. As discussed in chapter 5, during the chronological period addressed, there was significant migration from the country to the cities, hence the individuals from both rural and urban areas were largely from a similar background. Therefore, the social class system found in the countryside was also much present in the urban context. Additionally, values and behaviours associated with the social classes were the same whether one lived in a city, or in the countryside. Consequently, if one was to find major differences between individuals these would not necessarily reflect their rural or urban provenance, but rather their social class.

The main discussions concerning the results of the markers of occupational stress (MOS) have been addressed in the respective chapters (6 and 7). Only themes that are relevant to the framework of the assessment of gender from a palaeopathological perspective will be presented here. This final discussion will address the hypothesis raised at the beginning of the research. Two major arenas for debate are therefore addressed. One concerns the biological data of the analysis, which are the MOS. The other will address the social dimensions of the biological data. The social dimension analysis considered the importance of MOS within the framework of gender analysis.

With regard to the analysis of the MOS selected, the hypotheses addressed proved that the major differences found between men and women were not necessarily sex-related but were age biased. Throughout the analysis of the pathologies selected, age was one of the major confounding variables. Further to this bias another major issue to address was the nature of the MOS data. As discussed in chapter 3, many of the MOS selected for use as proxies to activity/occupation have been subjected to methodological re-evaluation. The methods used to asses the bony changes under analysis, as well as the theories that support their use, are in need of being updated. MOS methods need to be systematised and standardized.

Therefore bioarchaeology needs to develop its own models of analysis, as well as control experiments, and establish interdisciplinary studies on activity related changes. It is necessary to ascertain whether occupation analysis is achievable within a bioarchaeological context, to understand the skeletal changes in terms of the biomechanical forces that leave their mark on the human bones. Forces that may either shape the bone morphology or its architecture, such as observed in cross-sectional geometry, or may promote the growth of additional bone such as osteophytes or enthesopathies. This would be done within a framework of control for as many confounding variables as possible. Hopefully this would allow to address one of the major problems in bioarchaeological methods of research, namely its frequent "borrowing" of other disciplines' theories, models, definitions and data.

Non-bioarchaeological disciplines such as medicine, epidemiology, radiology and engineering can no longer be considered sufficient for future bioarchaeology as an independent discipline. The definition of what the bony changes actually represent in the human skeletons is something that needs to be defined within a bioarchaeological context. Furthermore, it is necessary to define what methods to use whilst analysing a particular bony change and which criteria to consider when making a diagnosis. It is also urgent to specify which anatomical features are to be used in the analysis of a particular condition in bioarchaeology. For instance, if one is analysing OA, how is a joint to be defined in a bioarchaeological context? This question is far more complicated than it may at first appear. As demonstrated in this research, the inclusion or not of the acromioclavicular articular facet in the analysis of the shoulder joint (chapter 6; section 6.1.2) significantly influences the results obtained. Therefore, one is to carefully define which articular surfaces are to be considered whilst analysing a particular joint, and what would be the best procedure in the absence of a particular joint anatomical compartment. Further to this, one also needs to consider what method to use, and which criteria to employ. As already referred to in chapter 3, there are several approaches to bony changes within the realm of bioarchaeological analysis. This creates confusion, and is of the upmost importance, particularly if the aim of bioarchaeological studies is to draw future comparisons.

Apart from the discussion concerning the methods used in MOS analysis, their viability as markers of physical activity is another issue that needs to be discussed. Analogies with clinical data have proved that there is a relationship between certain types of physical activity and certain pathological conditions (see chapter 3 for examples). However, the extent to which these pathological conditions relate to the bony changes observable in the skeletons, and how activity influences these bony changes, is demonstrably an area that requires further debate. Ultimately one cannot confidently address physical activity based on the analysis of skeletal markers. The present study has identified two major reasons which call into question the reliability of the use of MOS as a definitive proxy for activity in past societies. The first is related to the occupational group in a broader sense, the second being specific to activities.

Some of the results achieved in this research identified significant relationships between particular groups of occupation and skeletal bony changes, as well as post cranial indices (chapter 7). However, the results found do not necessarily corroborate the assumption that occupations with a supposedly higher level of stress would exhibit higher values of lesions. For instance, in the Grouped_Variables results (chapter 7) individuals grouped as farmers and servants displayed some of the lower mean values of lesions, whilst unskilled workers were amongst the occupational groups with the higher values of lesions, closely followed by people working in commerce and transport. The fact that the unskilled workers had high values of lesions was expected, as there were individuals known to be engaged in strenuous work, as described in the chapter 5. Therefore, this reasoning would accord with the argument that the more strenuous a lifestyle, the more likely an individual would display MOS, particularly when compared to others who lived less strenuous lifestyles. However, the fact that farmers sometimes exhibited low values of lesions was not expected. In Portuguese society within the timeframe of this study, farmers were individuals who would have worked very long hours from a very young age. In many ways farmers and unskilled workers would share a similar lifestyle. In fact, many of the activities performed by unskilled workers would probably be related to farming.

My second point addresses the argument that the occupational group may be too broad, and may therefore "hide" some of the activity-specific differences between groups. Such an assumption appeared to be an over-simplification of the matter, necessitating further enquiry. To evaluate this assumption a sub-sample of 48 individuals was selected and occupational-specific differences were tested. The results show the absence of any significant association between specific activity and the variables tested (chapter 7, section 7.1.3.2). The results of these tests confirmed that occupational groups may not necessarily hide activity-specific skeletal lesions, as these activity-specific skeletal lesions may be absent in the skeletons.

Although the theoretical assumption that MOS can be used to identify occupational group differences was proven correct in the sample, the assumption that MOS may be activity specific was not. Therefore, to presume that occupational groups may hide activity-specific lesions may be misguided. On the other hand, the statistically significant differences found between the occupational groups within this sample may not necessary be related to specific activities, but to other confounding variables not accounted for in this study. These may include social-economic status, dietary intake, genetic inheritance and other influential factors as highlighted in chapter 3. Therefore, one should consider alternative explanations for the lack of association found between specific occupations and degenerative bony changes associated with joints and entheses, or even cross-sectional geometry. Maybe these so called markers of occupational stress may not be the best proxies to study activity/occupation in past populations. In conclusion, bioarchaeology needs to refine its methods, in order to test whether or not one can infer general or specific occupations/activity from human skeletal remains.

Ultimately, one is led to question the possibility of ever being able to fully assess occupational/activity-related changes in human skeletons. The central stumbling block will always be the lack of a detailed biography of the individuals. It is not enough to know the occupation of the individuals at the time of his/her death. The final occupation of an individual may have little or no relevance to an individual's lifestyle history. It certainly may not bear any strong correlation with the skeletal markers displayed by his/her remains. One needs to know a person's activities throughout their lifetime to have any hope of understanding how these activities affected their skeletons. Details of when an individual started to perform activities, for how long, how often, and the degree of strenuousness will always be needed. One should also consider the specific "performative demand" of each activity. All of these factors should be considered whilst controlling for variables such as age, sex, social and dietary status and ethnicity. Specificities of the pathological condition, or degenerative bony changes under analysis, should also be controlled for. For instance, if analysing changes in the joints, the morphology of the various anatomical compartments within the joints should also be considered as these are known to influence OA results (as discussed in Chapter 3).

In a bioarchaeological context the assessment of a person's life history is an impossibility. Rare exceptions may occur if one has access to identified skeletal collections such as CISC, LLSC and Spitalfields (Cardoso, 2005, 2006; Cox, 1996; Cunha, 1995; Cunha and Umbelino, 1995; Molleson and Cox, 1993), if one has the resource of an individual's personal archive, but for the majority of bioarchaeological data, such records would be unavailable. Typically, one may only achieve general inferences drawn from historical, archaeological or ethnohistorical contexts. Even with a multidisciplinary approach to human skeletal remains, one cannot replace the importance on a skeleton's "life history". Hence, within the actual context of bioarchaeological research, and whilst the discipline's methods are not reassessed, one can only provide general statements about activity in the past without ever being able to prove these statements correct.

Hence, to turn from the biological to the social ramifications of the present study, the confident portrayal of gender through the analysis of MOS is impossible. There are too many problems associated with the MOS used in this research, and in addition, with the sample itself. The main problem related to the sample was the overwhelming lack of description regarding female's occupations. The fact that the majority of women were reported as being *domésticas* (housewives) was a major handicap in gender analysis based on activity-related skeletal changes. According to the identified skeletal records, 91.1% (276/303) of the women used in the current analysis were performing/employed in house-related tasks. Indeed, the inability to effectively distinguish between paid employment and familial household work only served to further the obfuscation regarding women's roles. Therefore, no major inferences were allowed about MOS and female activities.

When comparing MOS and the female occupational group, this displayed one of the lower mean values of lesions when compared to the other occupational groups. The interpretation would be that women were engaged in activities that convey lower values of activity-related changes. However, such affirmation was proven to be overly simplistic and non representative of reality. In the current sample, and based on the data provided on chapter 5, women and men of low socio-economical status would be subjected to similar levels of deprivation and access to resources. Most importantly, they would be subjected to the same physical demands. Yet if the underlying assumption of MOS is that the more physically demanding a lifestyle, the higher the value/frequency of MOS, then low social economic status individuals, which would include housewives, farmers and unskilled workers should exhibit similar values of MOS. This was not the case in the present study.

Therefore, if major differences were to be found in the 19th and early to mid 20th century, most would be related to matter of the social hierarchy of the population rather than with one's gender. Different social-economical status may have a higher impact on the human skeleton than activity. As gender is essentially a socially performed phenomenon, it can never be assessed solely through the examination of physical remains. The social dimension as one of performance is difficult to ascertain in something as static as bones, or human skeletons. Bioarchaeology only has access to the end results of a lifetime of an individual's interaction with the environment and culture. One cannot account for an individual personal history, as one might have hoped. Even the relationship between material culture and the identity of the deceased person is acknowledged to be complex nowadays. Consequently, what was once a straightforward exercise of identifying status or gender based on material culture is no longer acceptable, particularly if one recognizes that grave goods are related to the mourners. Within a burial context, the burial act, the presentation of the corpses, the form of the funerary rites might have as much more to do with the living renegotiating their respective position in the wake of the death, than with the deceased individual *per se* (Barrett, 1999; King, 2004; Lucy, 1999; Pearson, 1999).

Hence, as gender can *never* be confidently assessed, a more reliable and fruitful method of analysing the social dimension of bioarchaeological data, particularly within the context of identified skeletal collections, would be to focus on social hierarchy and *not* gender. Further study on the health status of the individuals would positively contribute to this "research strategy", of assessing the social and cultural dimension of human beings.

Chapter 9: Conclusions

With regard to the skeletal markers used to assess occupation, the major conclusion drawn from this research focuses on the need for further development of new methods. These new methods need to be based on clinical analogies, but developed in conjunction with bioarchaeologists or in bioarchaeological contexts. As argued by Waldron (2001), bioarchaeologists need to be less of an historian, and more of a scientist. The description of pathological lesions is no longer enough, as the assumptions developed need to be tested, and experimental models need to be based on strong, fundamental experiments. One of the major aims of future bioarchaeological research should be to control for many of the confounding variables, such as sex, age, genetics and diet which are influential factors in many of the pathological conditions used to assess behaviour. This was observed in the results achieved in the current research. In the case of the analysis of the degenerative changes by sex sub-sample, many results were found to be statistically significant; however, when age at death of the individuals was controlled for, the significance levels were often no longer attained. These examples illustrate the need for caution, and a conservative approach towards the interpretation of the data.

It is significant to question whether one should move forward, and undertake a meta-analysis of existing data. This would imply the reanalysis of many of the research done in the past, as the data collected in previous research, as well as the methods used, varied. Therefore if one is to aim for comparative studies between populations, it is necessary to standardize the research. Only after such an exercise will it be possible to fully rely upon such comparative studies. If bioarchaeology is inherently a "comparative exercise", one needs to ascertain that such comparisons are valid (Wright and Yoder, 2003: 57). This raises a very important issue: what is the value of the previous research done? Regardless of the angle from which we approach this question, it is undeniable that bioarchaeology has come a long way, and some of the issues raised in this research, as well as other more critical studies, would not exist without a past. Therefore, the research done in the past should be regarded as contextual. It was important in its time, and relevant for the development of the discipline. It helped to narrow the gap between anthropology, archaeology, medicine, history and other social sciences. Bioarchaeology functioned as a multidisciplinary approach to the past of human societies, and despite its theoretical and methodological limitations one cannot ignore its importance, or contribution to the human knowledge. However, it is time for a new period of introspection and debate (Wright and Yoder, 2003), as the one provoked by the emergence of the "osteological paradox" in 1992. Should we call it going back to basics?

The research being currently undertaken in bioarchaeological contexts is inherently flawed. Many of the studies do not account for the heterogeneity, and complex aetiologies of the pathological lesions under analysis. Furthermore, as discussed in chapter 3, many of the methods used are hardly representative of the conditions they aim to quantify. Therefore, as an interdisciplinary science bioarchaeology needs to redefine its methods, developing its own experimental models, always revising and continuously updating. Bioarchaeology must maintain an active engagement in related changes and controversies emerging within relevant disciplines such as medicine, epidemiology, engineering, social sciences and others. This constant re-evaluation of the core constructs of bioarchaeology can prevent the propagation of unsustainable conclusions.

This re-evaluation of MOS has further implications for the social dimension of the analysis. In the current sample, it was impossible to assess gender based on the skeletal marks. This was brought about by fundamental flaws in the inherent limitations in current MOS methods and the fact that gender is a *social construction* rather than being a *biologically identifiable trait* in skeletal material. It is a very big jump to draw inferences on the social dimension of past human societies based on bioarchaeological changes. The changes analysed in the skeletons tell little about a person's biographical story, and without such biographical detail I believe that it is impossible to infer any type of occupational related skeletal marks. Ultimately, the use of skeletal marks or, as highlighted throughout the present work, *Markers of Occupational Stress*, to portray gender in late 19th and early 20th century Portuguese Population is an impossible task.

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Appendices

Appendices Content

Index of Tables

1.1 Appendix _ Material

Table 1 - Causes of death in Portugal for the years of 1946 (I.N.E. 1946: 26) and 1966 (I.N.E. 1966a: 28) . Note the increase in denomination of causes of death, as well as in number of cases.

Movimento fisiológico — PORTUGAL

Número de ordem	Idades e sexos / *Ages et sexes* — Causas de morte / *Causes de décès* — Nomenclatura abreviada / *Nomenclature abrégée*	Totais / *Totaux* HM	H	M
		1	2	3
	Total	115.595	58.717	56.878
1	Febres tifóide e paratifóides	1.321	622	699
2	Tifo exantemático	16	7	9
3	Varíola	46	30	16
4	Sarampo	317	172	145
5	Escarlatina	17	6	11
6	Tosse convulsa ou *coqueluche*	565	246	319
7	Difteria	790	432	358
8	Gripe ou *influenza*	837	423	414
9	Peste	31	11	20
10	Tuberculose do aparelho respiratório	10.458	6.112	4.346
11	Tôdas as outras tuberculoses	1.878	951	927
12	Sífilis	477	257	220
13	Paludismo (malária ou sezonismo)	248	150	98
14	Outras doenças infeciosas e parasitárias	2.011	1.145	866
15	Cancro e outros tumores malignos	3.690	1.652	2.038
16	Tumores não malignos ou cujo carácter maligno não foi especificado	339	192	147
17	Reumatismo crónico e gota	296	127	169
18	Diabetes	426	188	238
19	Alcoolismo crónico ou agudo	336	271	65
20	Outras doenças gerais e envenenamentos crónicos	1.028	526	502
21	Ataxia locomotriz progressiva (tabes dorsal) e paralisia geral	246	137	109
22	Hemorragia cerebral, embolia ou trombose cerebral	8.454	3.836	4.618
23	Outras doenças do sistema nervoso e dos órgãos dos sentidos (nas idades até 5 anos)	1.187	681	506
23 b	Outras doenças do sistema nervoso e dos órgãos dos sentidos (nas idades superiores a 5 anos)	1.189	657	532
24	Doenças do coração	12.304	6.572	5.732
25	Outras doenças do aparelho circulatório	1.764	921	843
26	Bronquite	1.947	1.084	863
27	Pneumonias	8.291	4.473	3.818
28	Outras doenças do aparelho respiratório excepto tuberculose	1.356	868	488
29	Diarreia e Enterite (nas idades inferiores a 2 anos)	12.351	6.671	5.680
29 b	Diarreia e Enterite (a partir dos 2 anos de idade)	2.748	1.345	1.403
30	Apendicite	167	111	56
31	Doenças do fígado e das vias biliares	1.905	1.128	777
32	Outras doenças do aparelho digestivo	2.494	1.587	907
33	Nefrites (nas idades até 10 anos)	486	245	241
33 b	Nefrites (nas idades superiores a 10 anos)	1.972	1.020	952
34	Outras doenças dos aparelhos urinário e genital	332	263	69
35	Septicémia e infecções puerperais	302	..	302
36	Outras doenças da gravidez, do parto e do estado puerperal	368	..	368
37	Doenças da pele, do tecido celular, dos ossos e dos órgãos da locomoção	494	294	200
38	Debilidade congénita, vícios de conformação congénitos, nascimento prematuro, etc.	7.830	4.599	3.231
39	Senilidade	10.530	3.954	6.576
40	Suicídio	776	575	201
41	Homicídio	157	137	20
42	Morte violenta ou acidental (excepto suicídio e homicídio)	2.960	2.068	892
43	Causas não especificadas ou mal definidas	8.379	4.486	3.893
	1944	119.278	61.800	57.478

Movimento da população — *Mouvement de la population*

Distritos e sexo / *Districts et sexe* — Causas de morte (lista abreviada) / *Causes de décès (liste abrégée)*	Total HM	H	M
1	2	3	4
TOTAL	96 187	49 928	46 259
B 1 Tuberculose do aparelho respiratório	2 504	1 923	581
B 2 Tuberculose, outras formas	258	153	105
B 3 Sífilis e suas sequelas	177	115	62
B 4 Febre tifóide	34	20	14
B 5 Cólera	..	..	..
B 6 Disenteria, todas as formas	7	5	2
B 7 Escarlatina e angina estreptocócica	21	10	11
B 8 Difteria	112	45	67
B 9 Tosse convulsa	36	14	22
B 10 Infecções meningocócicas	169	105	64
B 11 Peste	..	..	..
B 12 Poliomielite aguda	30	18	12
B 13 Varíola	..	..	..
B 14 Sarampo	192	102	90
B 15 Tifo e outras doenças por Rickettsias	(a) 1	1	..
B 16 Sezonismo	1	..	1
B 17 Todas as outras doenças infecciosas e parasitárias	592	325	267
B 18 Tumores malignos, incluindo os tumores dos tecidos linfáticos e hematopoiéticos	9 890	4 946	4 944
B 19 Tumores benignos e tumores de natureza não especificada	111	41	70
B 20 Diabetes mellitus	852	236	616
B 21 Anemias	101	47	54
B 22 Lesões vasculares afectando o sistema nervoso central	14 310	6 360	7 950
B 23 Meningite não meningocócica	191	99	92
B 24 Reumatismo articular agudo	49	18	31
B 25 Doença crónica reumatismal do coração	1 219	542	677
B 26 Doença arteriosclerótica e degenerativa do coração	10 749	5 195	5 554
B 27 Outras doenças do coração	403	226	177
B 28 Hipertensão com doença do coração	1 434	628	806
B 29 Hipertensão sem menção de doença do coração	522	218	304
B 30 Influenza	625	280	345
B 31 Pneumonia	7 852	4 206	3 646
B 32 Bronquite	2 726	1 613	1 113
B 33 Úlcera do estômago e do duodeno	826	622	204
B 34 Apendicite	81	46	35
B 35 Obstrução intestinal e hérnia	372	206	166
B 36 Gastrite, duodenite, enterite e colite, excepto a diarreia do recém-nascido	4 684	2 560	2 124
B 37 Cirrose do fígado	2 804	1 824	980
B 38 Nefrite e nefrose	1 872	979	893
B 39 Hipertrofia da próstata	212	212	—
B 40 Complicações da gravidez, do parto e do estado puerperal	178	—	178
B 41 Malformações congénitas	646	349	297
B 42 Lesões devidas ao parto, asfixia e atelectasia pós-natais	1 032	627	405
B 43 Infecções do recém-nascido	1 251	717	534
B 44 Outras doenças particulares da primeira infância e prematuridade não qualificada	2 430	1 387	1 043
B 45 Senilidade sem menção de psicose e causas mal definidas e desconhecidas	14 368	8 852	5 516
B 46 Todas as outras doenças	4 517	2 513	2 004
Acidentes, envenenamentos e violências:			
Causas externas			
BE 47 Acidentes com veículos automóveis	1 267	1 008	259
BE 48 Todos os outros acidentes	2 349	1 716	633
BE 49 Suicídio e lesão infligida a si próprio	839	659	180
BE 50 Homicídio e traumatismo proveniente de operações de guerra	91	62	29
Natureza do traumatismo:			
BN 47 *Fracturas, traumatismo da cabeça e lesões traumáticas internas*	2 506	1 895	611
BN 48 *Queimaduras*	330	116	214
BN 49 *Efeitos de venenos*	171	103	68
BN 50 *Todas as outras lesões*	1 730	1 327	403

(a) Caso de febre escaro-nodular — *Cas de fièvre boutonneuse.*

Table 2 – Detailed males occupations.

Occupation	N	%	Occupation	N	%	Occupation	N	%
Army	18	6,0	Gaffer	1	0,3	Roadmender	3	1,0
Baker	6	2,0	Gardner	1	0,3	Salesman	2	0,7
Bank clerk	3	1,0	Gilder	1	0,3	Salesperson	1	0,3
Barber	5	1,7	Glass blower	1	0,3	Sawyer	1	0,3
Basket weaver	1	0,3	Gravedigger	1	0,3	Scribe	1	0,3
Blacksmith	1	0,3	Hospital employee	1	0,3	Servant	3	1,0
Bricklayer	8	2,7	Industrial	8	2,7	Shoemaker	12	4,0
Building constructor	1	0,3	Insurance worker	2	0,7	Shop assistant	25	8,3
Caretaker	2	0,7	Locksmith	3	1,0	Solicitor	1	0,3
Carpenter	15	5,0	Mechanic	1	0,3	Stallman	1	0,3
Carrier / worker	1	0,3	Merchant	9	3,0	Stoker	1	0,3
Chauffeur	2	0,7	Navy	5	1,7	Stonemason	1	0,3
City Council employee	2	0,7	Newspaper man	1	0,3	Student	1	0,3
Civil servant	13	4,3	Nurse	1	0,3	Tailor	3	1,0
Clerk	6	2,0	Orchestra conductor	1	0,3	Tanner	1	0,3
Coach driver	3	1,0	Owner/proprietor	5	1,7	Teacher	3	1,0
Comercial agent	2	0,7	Painter	7	2,3	Tinsmith	3	1,0
Coppersmith	2	0,7	Pantry keeper	1	0,3	Toothpick artisan	1	0,3
Corporation employee	1	0,3	Pedlar	2	0,7	Turner	1	0,3
Court officer	1	0,3	Pharmaceutical	1	0,3	Upholsterer	1	0,3
Cutter	2	0,7	Pharmacy assistant	1	0,3	Wagoner	2	0,7
Doorman	1	0,3	Photographer	2	0,7	Weaver	1	0,3
Draughtsman	2	0,7	Botanist	1	0,3	Wireman	1	0,3
Driver	1	0,3	Plumber	2	0,7	Worker	24	8,0
Electrician	5	1,7	Police officer	14	4,7			
Errand boy	3	1,0	Post Office worker	2	0,7			
Factory worker	4	1,3	Postman	1	0,3			
Farmer	3	1,0	Potter	1	0,3			
Fishmonger	1	0,3	Printer	4	1,3			
Foundry worker	2	0,7	Railway employee	8	2,7			

1.2 Appendix _DBC

Table 3 – Descriptive statistics of the degenerative bones changes observed, per articular surface, according to sex. Reference to total number of cases observed (N), average of the degree of lesions (Mean) and Standard deviation (S.D.).

				Left side												Right side											
				Marginal lipping			Porosity			Osteophytes			Eburnation			Marginal lipping			Porosity			Osteophytes			Eburnation		
Joint	Bone			N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Shoulder	Clavicle	Acromion	Female	248	0.472	0.747	248	1.157	1.318	248	0.036	0.227	248	0.073	0.435	239	0.427	0.740	240	1.150	1.308	240	0.067	0.336	240	0.088	0.480
			Male	221	0.308	0.629	222	1.279	1.363	222	0.041	0.257	222	0.036	0.299	236	0.398	0.751	236	1.445	1.375	236	0.034	0.223	236	0.089	0.484
			Total	469	0.394	0.698	470	1.215	1.339	470	0.038	0.241	470	0.055	0.377	475	0.413	0.745	476	1.296	1.348	476	0.050	0.286	476	0.088	0.482
	Scapula	Acromion	Female	250	0.432	0.732	250	0.604	1.097	250	0.024	0.218	250	0.092	0.503	240	0.600	0.886	240	0.746	1.213	240	0.029	0.192	240	0.083	0.450
			Male	241	0.344	0.627	241	0.726	1.165	241	0.008	0.129	241	0.071	0.446	247	0.466	0.748	247	0.887	1.289	247	0.004	0.064	247	0.105	0.538
			Total	491	0.389	0.683	491	0.664	1.132	491	0.016	0.180	491	0.081	0.475	487	0.532	0.821	487	0.817	1.253	487	0.016	0.142	487	0.094	0.496
	Scapula	Glenoid cavity	Female	296	0.956	0.853	296	0.301	0.786	296	0.166	0.530	296	0.030	0.301	293	0.945	0.890	293	0.157	0.526	293	0.106	0.421	293	0.027	0.273
			Male	290	0.866	0.827	290	0.117	0.408	290	0.121	0.466	290	0.003	0.059	289	0.910	0.869	289	0.114	0.413	289	0.125	0.462	289	0	0
			Total	586	0.911	0.841	586	0.210	0.634	586	0.143	0.500	586	0.017	0.218	582	0.928	0.879	582	0.136	0.474	582	0.115	0.442	582	0.014	0.194
	Humerus	Proximal end	Female	289	0.626	0.767	292	0.178	0.571	292	0.089	0.387	292	0.058	0.406	287	0.686	0.775	287	0.101	0.418	287	0.063	0.318	287	0.042	0.352
			Male	285	0.460	0.699	287	0.059	0.236	287	0.066	0.333	287	0	0	290	0.479	0.687	291	0.062	0.293	291	0.055	0.306	291	0.007	0.117
			Total	574	0.544	0.738	579	0.119	0.442	579	0.078	0.361	579	0.029	0.290	577	0.582	0.739	578	0.081	0.361	578	0.059	0.312	578	0.024	0.262
Elbow	Humerus	Distal end	Female	286	0.476	0.714	292	0.315	0.810	292	0.185	0.537	292	0.123	0.579	283	0.562	0.683	285	0.305	0.779	285	0.218	0.589	285	0.077	0.421
			Male	279	0.373	0.633	284	0.225	0.650	284	0.141	0.469	284	0.046	0.338	285	0.428	0.638	290	0.193	0.580	290	0.197	0.570	290	0.024	0.255
			Total	565	0.425	0.676	576	0.271	0.736	576	0.163	0.505	576	0.085	0.477	568	0.495	0.664	575	0.249	0.688	575	0.207	0.579	575	0.050	0.348
	Radius	Proximal end	Female	274	0.321	0.731	285	0.172	0.577	285	0.102	0.411	285	0.112	0.545	267	0.326	0.732	277	0.184	0.630	277	0.119	0.447	277	0.083	0.439
			Male	275	0.171	0.479	288	0.052	0.278	288	0.090	0.390	288	0.042	0.331	267	0.213	0.591	280	0.068	0.348	280	0.121	0.455	280	0.021	0.253
			Total	549	0.246	0.622	573	0.112	0.456	573	0.096	0.400	573	0.077	0.452	534	0.270	0.667	557	0.126	0.511	557	0.120	0.451	557	0.052	0.359
	Ulna	Proximal end	Female	287	0.672	0.826	292	0.168	0.571	292	0.089	0.405	292	0.031	0.303	290	0.752	0.840	290	0.172	0.568	290	0.072	0.340	290	0.007	0.117
			Male	289	0.536	0.712	292	0.079	0.394	292	0.041	0.272	292	0	0	290	0.662	0.778	293	0.058	0.310	293	0.031	0.225	293	0	0
			Total	576	0.604	0.773	584	0.123	0.492	584	0.065	0.345	584	0.015	0.215	580	0.707	0.810	583	0.115	0.460	583	0.051	0.289	583	0.003	0.083
Wrist	Radius	Distal end	Female	279	0.355	0.605	283	0.046	0.306	283	0.025	0.196	283	0.011	0.178	285	0.358	0.586	287	0.052	0.336	287	0.014	0.167	287	0.017	0.212
			Male	291	0.326	0.605	292	0.027	0.183	292	0.007	0.117	292	0.041	0.349	285	0.333	0.620	285	0.035	0.276	285	0.018	0.177	285	0.046	0.348
			Total	570	0.340	0.605	575	0.037	0.251	575	0.016	0.161	575	0.026	0.279	570	0.346	0.603	572	0.044	0.307	572	0.016	0.172	572	0.031	0.288
	Ulna	Distal end	Female	260	0.227	0.588	261	0.084	0.473	261	0.042	0.281	261	0.065	0.401	262	0.317	0.639	264	0.095	0.456	264	0.038	0.244	264	0.061	0.395
			Male	273	0.234	0.591	273	0.110	0.448	273	0.055	0.310	273	0.029	0.270	277	0.325	0.661	277	0.054	0.257	277	0.079	0.352	277	0.061	0.390
			Total	533	0.231	0.589	534	0.097	0.460	534	0.049	0.296	534	0.047	0.341	539	0.321	0.650	541	0.074	0.368	541	0.059	0.305	541	0.061	0.392
Hip	Coxal	*Acetabulum*	Female	299	1.502	0.825	299	0.562	1.036	299	0.114	0.457	299	0.007	0.116	301	1.532	0.818	300	0.657	1.106	301	0.146	0.502	301	0.040	0.344
			Male	292	1.438	0.833	292	0.616	1.079	292	0.236	0.622	292	0	0	295	1.447	0.789	295	0.634	1.095	295	0.285	0.680	295	0.024	0.209
			Total	591	1.470	0.829	591	0.589	1.057	591	0.174	0.548	591	0.003	0.082	596	1.490	0.804	595	0.645	1.100	596	0.215	0.600	596	0.032	0.285
	Femur	Proximal end	Female	296	0.753	0.734	299	0.318	0.735	299	0.221	0.578	299	0.023	0.251	294	0.837	0.793	298	0.336	0.792	298	0.245	0.623	298	0.040	0.346
			Male	293	0.696	0.776	296	0.277	0.702	296	0.304	0.695	296	0	0	296	0.750	0.767	298	0.305	0.728	298	0.319	0.703	298	0.023	0.238
			Total	589	0.725	0.755	595	0.297	0.718	595	0.262	0.640	595	0.012	0.178	590	0.793	0.780	596	0.320	0.760	596	0.282	0.664	596	0.032	0.297
Knee	Femur	Distal end	Female	299	0.860	0.941	300	0.300	0.791	300	0.393	0.771	300	0.123	0.574	299	0.943	0.948	300	0.333	0.807	300	0.423	0.791	300	0.187	0.688
			Male	296	0.561	0.706	296	0.199	0.586	296	0.179	0.551	296	0.037	0.311	296	0.628	0.766	298	0.174	0.553	298	0.195	0.571	298	0.077	0.461
			Total	595	0.711	0.845	596	0.250	0.698	596	0.287	0.679	596	0.081	0.464	595	0.787	0.876	598	0.254	0.696	598	0.309	0.699	598	0.132	0.588
	Tibia	Proximal end	Female	296	0.703	0.871	299	0.120	0.484	299	0.094	0.399	299	0.050	0.368	298	0.711	0.923	301	0.120	0.482	301	0.123	0.449	301	0.086	0.496
			Male	292	0.445	0.684	296	0.061	0.279	296	0.068	0.333	296	0	0	292	0.514	0.780	297	0.077	0.335	297	0.088	0.393	297	0.030	0.300
			Total	588	0.575	0.794	595	0.091	0.396	595	0.081	0.367	595	0.025	0.262	590	0.614	0.860	598	0.099	0.416	598	0.105	0.422	598	0.059	0.411
	Patella		Female	268	0.869	0.862	270	0.367	0.864	270	0.293	0.695	270	0.089	0.487	264	0.909	0.876	264	0.326	0.804	264	0.258	0.642	264	0.159	0.651
			Male	271	0.664	0.771	273	0.139	0.538	273	0.136	0.500	273	0.029	0.270	266	0.677	0.815	267	0.124	0.486	267	0.135	0.487	267	0.034	0.317
			Total	539	0.766	0.823	543	0.252	0.727	543	0.214	0.609	543	0.059	0.394	530	0.792	0.853	531	0.224	0.671	531	0.196	0.572	531	0.096	0.514
Ankle	Tibia	Distal end	Female	300	0.313	0.525	301	0.027	0.257	301	0.010	0.129	301	0.020	0.244	297	0.384	0.588	298	0.013	0.141	298	0.023	0.208	298	0	0
			Male	296	0.318	0.508	298	0.013	0.115	298	0.020	0.200	298	0	0	297	0.438	0.596	298	0.070	0.391	298	0.054	0.302	298	0	0
			Total	596	0.315	0.516	599	0.020	0.199	599	0.015	0.168	599	0.010	0.173	594	0.411	0.592	596	0.042	0.295	596	0.039	0.260	596	0	0
	Fibula	Distal end	Female	292	0.041	0.199	292	0.010	0.131	292	0.010	0.131	292	0	0	291	0.045	0.223	292	0.010	0.131	292	0.010	0.131	292	0	0
			Male	290	0.072	0.273	290	0.007	0.083	290	0.007	0.117	290	0	0	290	0.062	0.256	290	0.017	0.155	290	0.007	0.083	290	0	0
			Total	582	0.057	0.239	582	0.009	0.109	582	0.009	0.124	582	0	0	581	0.053	0.240	582	0.014	0.143	582	0.009	0.109	582	0	0

Table 4 - Descriptive statistics of the degenerative bones changes observed, per articular surface, according to skeletal collection. Present are: total number of cases observed (N), average of the degree of lesions (Mean) and Standard deviation (S.D.).

				Left side												Right side											
				Marginal lipping			Porosity			Osteophytes			Eburnation			Marginal lipping			Porosity			Osteophytes			Eburnation		
Joint	Bone			N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Shoulder	Clavicle	Acromion	Lisbon	250	0.480	0.808	251	1.271	1.338	251	0.024	0.199	251	0.060	0.390	242	0.537	0.888	243	1.465	1.334	243	0.037	0.246	243	0.103	0.516
			Coimbra	219	0.297	0.532	219	1.151	1.341	219	0.055	0.282	219	0.050	0.361	233	0.283	0.531	233	1.120	1.343	233	0.064	0.322	233	0.073	0.444
			Total	469	0.394	0.698	470	1.215	1.339	470	0.038	0.241	470	0.055	0.377	475	0.413	0.745	476	1.296	1.348	476	0.050	0.286	476	0.088	0.482
	Scapula	Acromion	Lisbon	241	0.465	0.790	241	0.793	1.165	241	0	0	241	0.100	0.523	240	0.658	0.942	240	0.929	1.290	240	0.021	0.143	240	0.129	0.582
			Coimbra	250	0.316	0.553	250	0.540	1.087	250	0.032	0.251	250	0.064	0.425	247	0.409	0.662	247	0.709	1.208	247	0.012	0.142	247	0.061	0.393
			Total	491	0.389	0.683	491	0.664	1.132	491	0.016	0.180	491	0.081	0.475	487	0.532	0.821	487	0.817	1.253	487	0.016	0.142	487	0.094	0.496
	Scapula	Glenoid cavity	Lisbon	296	1.111	0.927	296	0.199	0.597	296	0.182	0.559	296	0.020	0.246	294	1.133	0.949	294	0.143	0.503	294	0.180	0.540	294	0.017	0.210
			Coimbra	290	0.707	0.686	290	0.221	0.670	290	0.103	0.428	290	0.014	0.186	288	0.719	0.747	288	0.128	0.443	288	0.049	0.297	288	0.010	0.177
			Total	586	0.911	0.841	586	0.210	0.634	586	0.143	0.500	586	0.017	0.218	582	0.928	0.879	582	0.136	0.474	582	0.115	0.442	582	0.014	0.194
	Humerus	Proximal end	Lisbon	283	0.721	0.827	288	0.139	0.443	288	0.132	0.461	288	0.021	0.250	288	0.698	0.811	289	0.090	0.352	289	0.087	0.367	289	0.017	0.212
			Coimbra	291	0.371	0.593	291	0.100	0.440	291	0.024	0.210	291	0.038	0.325	289	0.467	0.640	289	0.073	0.370	289	0.031	0.241	289	0.031	0.305
			Total	574	0.544	0.738	579	0.119	0.442	579	0.078	0.361	579	0.029	0.290	577	0.582	0.739	578	0.081	0.361	578	0.059	0.312	578	0.024	0.262
Elbow	Humerus	Distal end	Lisbon	273	0.505	0.748	285	0.425	0.911	285	0.228	0.606	285	0.109	0.536	278	0.583	0.720	284	0.384	0.868	284	0.289	0.673	284	0.067	0.411
			Coimbra	292	0.349	0.593	291	0.120	0.465	291	0.100	0.372	291	0.062	0.411	290	0.410	0.595	291	0.117	0.407	291	0.127	0.456	291	0.034	0.273
			Total	565	0.425	0.676	576	0.271	0.736	576	0.163	0.505	576	0.085	0.477	568	0.495	0.664	575	0.249	0.688	575	0.207	0.579	575	0.050	0.348
	Radius	Proximal end	Lisbon	261	0.307	0.706	282	0.156	0.557	282	0.121	0.454	282	0.096	0.493	250	0.328	0.753	269	0.152	0.535	269	0.178	0.544	269	0.074	0.425
			Coimbra	288	0.191	0.530	291	0.069	0.325	291	0.072	0.340	291	0.058	0.407	284	0.218	0.578	288	0.101	0.487	288	0.066	0.333	288	0.031	0.281
			Total	549	0.246	0.622	573	0.112	0.456	573	0.096	0.400	573	0.077	0.452	534	0.270	0.667	557	0.126	0.511	557	0.120	0.451	557	0.052	0.359
	Ulna	Proximal end	Lisbon	281	0.819	0.861	289	0.176	0.589	289	0.111	0.443	289	0.021	0.249	286	0.944	0.877	289	0.176	0.589	289	0.080	0.349	289	0	0
			Coimbra	295	0.400	0.614	295	0.071	0.367	295	0.020	0.201	295	0.010	0.175	294	0.476	0.664	294	0.054	0.269	294	0.024	0.209	294	0.007	0.117
			Total	576	0.604	0.773	584	0.123	0.492	584	0.065	0.345	584	0.015	0.215	580	0.707	0.810	583	0.115	0.460	583	0.051	0.289	583	0.003	0.083
Wrist	Radius	Distal end	Lisbon	277	0.357	0.658	282	0.043	0.263	282	0.011	0.103	282	0.021	0.252	281	0.402	0.670	283	0.025	0.213	283	0.021	0.205	283	0.014	0.168
			Coimbra	293	0.324	0.550	293	0.031	0.239	293	0.020	0.202	293	0.031	0.303	289	0.291	0.526	289	0.062	0.377	289	0.010	0.131	289	0.048	0.370
			Total	570	0.340	0.605	575	0.037	0.251	575	0.016	0.161	575	0.026	0.279	570	0.346	0.603	572	0.044	0.307	572	0.016	0.172	572	0.031	0.288
	Ulna	Distal end	Lisbon	248	0.270	0.645	248	0.113	0.496	248	0.032	0.236	248	0.044	0.302	256	0.355	0.710	257	0.058	0.319	257	0.062	0.325	257	0.047	0.289
			Coimbra	285	0.196	0.534	286	0.084	0.427	286	0.063	0.340	286	0.049	0.371	283	0.290	0.590	284	0.088	0.407	284	0.056	0.286	284	0.074	0.466
			Total	533	0.231	0.589	534	0.097	0.460	534	0.049	0.296	534	0.047	0.341	539	0.321	0.650	541	0.074	0.368	541	0.059	0.305	541	0.061	0.392
Hip	Coxal	*Acetabulum*	Lisbon	297	1.650	0.837	297	0.721	1.148	297	0.273	0.660	297	0	0	301	1.668	0.785	301	0.811	1.203	301	0.326	0.712	301	0.023	0.251
			Coimbra	294	1.289	0.780	294	0.456	0.940	294	0.075	0.380	294	0.007	0.117	295	1.308	0.784	294	0.476	0.955	295	0.102	0.432	295	0.041	0.317
			Total	591	1.470	0.829	591	0.589	1.057	591	0.174	0.548	591	0.003	0.082	596	1.490	0.804	595	0.645	1.100	596	0.215	0.600	596	0.032	0.285
	Femur	Proximal end	Lisbon	296	0.963	0.808	299	0.472	0.844	299	0.408	0.751	299	0.003	0.058	296	1.020	0.815	300	0.467	0.886	300	0.407	0.755	300	0.020	0.245
			Coimbra	293	0.485	0.611	296	0.122	0.506	296	0.115	0.459	296	0.020	0.246	294	0.565	0.672	296	0.172	0.571	296	0.155	0.530	296	0.044	0.342
			Total	589	0.725	0.755	595	0.297	0.718	595	0.262	0.640	595	0.012	0.178	590	0.793	0.780	596	0.320	0.760	596	0.282	0.664	596	0.032	0.297
Knee	Femur	Distal end	Lisbon	299	0.953	0.929	299	0.351	0.815	299	0.435	0.797	299	0.127	0.577	300	1.037	0.944	301	0.349	0.809	301	0.435	0.792	301	0.163	0.640
			Coimbra	296	0.466	0.668	297	0.148	0.537	297	0.138	0.491	297	0.034	0.306	295	0.532	0.718	297	0.158	0.544	297	0.182	0.564	297	0.101	0.529
			Total	595	0.711	0.845	596	0.250	0.698	596	0.287	0.679	596	0.081	0.464	595	0.787	0.876	598	0.254	0.696	598	0.309	0.699	598	0.132	0.588
	Tibia	Proximal end	Lisbon	296	0.841	0.894	301	0.140	0.477	301	0.126	0.452	301	0.040	0.324	297	0.902	0.962	302	0.149	0.497	302	0.169	0.523	302	0.070	0.452
			Coimbra	292	0.305	0.562	294	0.041	0.283	294	0.034	0.246	294	0.010	0.175	293	0.321	0.619	296	0.047	0.304	296	0.041	0.270	296	0.047	0.365
			Total	588	0.575	0.794	595	0.091	0.396	595	0.081	0.367	595	0.025	0.262	590	0.614	0.860	598	0.099	0.416	598	0.105	0.422	598	0.059	0.411
	Patella		Lisbon	251	1.028	0.910	254	0.370	0.842	254	0.331	0.734	254	0.067	0.416	243	1.099	0.957	244	0.311	0.776	244	0.332	0.720	244	0.123	0.568
			Coimbra	288	0.538	0.661	289	0.149	0.591	289	0.111	0.451	289	0.052	0.374	287	0.533	0.652	287	0.150	0.556	287	0.080	0.370	287	0.073	0.464
			Total	539	0.766	0.823	543	0.252	0.727	543	0.214	0.609	543	0.059	0.394	530	0.792	0.853	531	0.224	0.671	531	0.196	0.572	531	0.096	0.514
Ankle	Tibia	Distal end	Lisbon	299	0.408	0.574	302	0.020	0.199	302	0.023	0.207	302	0	0	298	0.530	0.682	299	0.037	0.263	299	0.070	0.355	299	0	0
			Coimbra	297	0.222	0.432	297	0.020	0.200	297	0.007	0.116	297	0.020	0.246	296	0.291	0.455	297	0.047	0.325	297	0.007	0.082	297	0	0
			Total	596	0.315	0.516	599	0.020	0.199	599	0.015	0.168	599	0.010	0.173	594	0.411	0.592	596	0.042	0.295	596	0.039	0.260	596	0	0
	Fibula	Distal end	Lisbon	287	0.073	0.274	287	0.007	0.083	287	0.010	0.132	287	0	0	286	0.063	0.257	287	0.010	0.132	287	0.007	0.083	287	0	0
			Coimbra	295	0.041	0.198	295	0.010	0.130	295	0.007	0.116	295	0	0	295	0.044	0.222	295	0.017	0.153	295	0.010	0.130	295	0	0
			Total	582	0.057	0.239	582	0.009	0.109	582	0.009	0.124	582	0	0	581	0.053	0.240	582	0.014	0.143	582	0.009	0.109	582	0	0

Table 5 – Chi-square results: analysis of the relationship between sex and DBC according to articular surface analyzed.

The p-value was set at 0.05, exact two-tailed. The symbols represent the following: f – Fisher's exact test results was used because >20% of the cells had expected count less than 5; = - males and females possess the same number of cases; ♀ - only female individuals presented the lesion; ♂ - only male individuals presented the lesion. Cells without values correspond to cases were no observations were made.

Shoulder joint:

	Clavicle acromion surface			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	5.848	0.018	0.620	0.475
Porosity	0.380	0.579	2.801	0.097
Osteophytes	0.006	1	1	0.447
Eburnation	0.955	0.390	=	=

	Scapula acromion surface			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	0.717	0.424	1.183	0.297
Porosity	2.089	0.170	1.233	0.293
Osteophytes	f	0.624	f	0.065
Eburnation	0.511	0.602	0.004	0.989

	Glenoid cavity			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	1.092	0.309	0.413	0.553
Porosity	5.587	0.020	0.623	0.483
Osteophytes	1.679	0.225	0.139	0.745
Eburnation	f	0.624	♀	-

	Humerus proximal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	8.494	0.004	10.833	0.001
Porosity	5.897	0.018	1.157	0.306
Osteophytes	0.530	0.562	0.219	0.670
Eburnation	♀	-	f	0.214

Elbow joint:

	Humerus distal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	2.490	0.129	5.632	0.021
Porosity	0.822	0.416	1.903	0.196
Osteophytes	0.956	0.343	0.346	0.611
Eburnation	2.470	0.161	3.982	0.053

	Radius proximal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	4.385	0.038	4.183	0.053
Porosity	8.529	0.004	6.1	0.015
Osteophytes	0.148	0.727	0.001	1
Eburnation	3.047	0.09	6.480	0.012

	Ulna proximal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	1.169	0.314	0.248	0.678
Porosity	5.028	0.034	8.514	0.004
Osteophytes	2.42	0.181	3.400	0.072
Eburnation	♀	-	[illegible]	-

Wrist joint:

	Radius distal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	0.736	0.402	1	0.266
Porosity	0.104	0.798	1	0.602
Osteophytes	f	0.118	f	0.685
Eburnation	f	0.373	f	0.285

	Ulna distal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	0.054	0.905	0.066	0.839
Porosity	3.907	0.056	0.106	0.844
Osteophytes	0.487	0.603	2.646	0.128
Eburnation	0.979	0.373	0.008	1

Hip joint:

	Femur proximal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	2.311	0.136	1.217	0.278
Porosity	1.170	0.300	0.010	1
Osteophytes	0.921	0.365	1.490	0.267
Eburnation	♀	-	f	1

	Acetabulum			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	0.496	0.485	0.009	1
Porosity	0.207	0.650	0.156	0.723
Osteophytes	9.123	0.003	7.540	0.008
Eburnation	♀	-	f	0.750

Knee joint:

	Femur distal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	4.724	0.033	8.469	0.004
Porosity	0.541	0.492	4.982	0.031
Osteophytes	14.787	<0.001	15.759	<0.001
Eburnation	4.280	0.060	6.373	0.017

	Tibia proximal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	7.043	0.009	3.952	0.053
Porosity	1.270	0.321	0.354	0.632
Osteophytes	0.520	0.575	1.686	0.241
Eburnation	♀	-	2.980	0.142

	Patella			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	4.879	0.031	[illegible]	0.003
Porosity	13.683	0.001	11.001	0.001
Osteophytes	10.058	0.002	7.127	0.002
Eburnation	2.027	0.172	9.378	0.009

Ankle joint:

	Tibia distal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	0.141	0.719	1.878	0.199
Porosity	=	=	5.539	0.033
Osteophytes	f	0.685	2.633	0.174
Eburnation	♀	-	-	-

	Fibula distal end			
	Left		Right	
	χ^2	p	χ^2	p
Marginal lipping	2.175	0.150	0.926	0.349
Porosity	=	=	f	0.426
Osteophytes	f	0.733	=	=
Eburnation	-	-	-	-

Several statistically significant associations were found between sex and DBC as it can be observed in the above tables. The majority of statistically significant cases were related to the presence of marginal lipping and porosity. Association between osteophytes and specifically eburnation and sex were a rarity. The joints with major differences between sexes were the knee, followed by the elbow and shoulder. No significant differences were found on the wrist joint. In the majority of cases, even those where no statistical significance was achieved, the probability of women exhibiting BDC was higher than for men. A few exceptions were recorded.

Table 6 - Wilcoxon signed rank test results: bilateral asymmetry of degenerative bony changes per articular surface according to sex sub-samples.

			Female								Male							
			Marginal lipping		Porosity		Osteophytes		Eburnation		Marginal lipping		Porosity		Osteophytes		Eburnation	
	Bone	Articular surface	Z	p	Z	p	Z	p	Z	p	Z	p	Z	p	Z	p	Z	p
Shoulder	Clavicle	Acromion	-0,202	0,865	-0,389	0,705	-2,864	0,004	-0,265	0,933	-2,077	0,038	-2,668	0,009	-0,132	0,894	-1,732	0,127
	Scapula	Acromion	-2,867	0,004	-1,346	0,182	-0,187	1,000	-1,342	0,374	-2,869	0,002	-2,344	0,018	-0,447	1,000	-1,112	0,330
	Scapula	Glenoid cavity	-0,179	0,906	-3,711	0,000	-1,514	0,145			-1,289	0,199	-0,100	0,896	-0,228	0,875		
	Humerus	Humeral head	-2,044	0,043	-2,415	0,016	-1,488	0,174			-0,601	0,605	0,000	1,000	-0,910	0,427		
Elbow	Humerus	Distal end	-2,154	0,038	-0,349	0,738	-0,803	0,444	-1,562	0,124	-1,001	0,334	-0,922	0,366	-1,315	0,214	-1,169	0,317
	Radius	Proximal end	-0,419	0,679	-0,243	0,801	-0,743	0,500	-0,554	0,597	-0,748	0,465	-0,645	0,508	-1,265	0,237	-0,962	0,441
	Ulna	Proximal end	-1,688	0,099	-0,242	0,837	-0,383	0,767			-3,144	0,002	-0,935	0,384	-0,692	0,586		
Wrist	Radius	Distal end	-0,400	0,750	-0,254	0,873					-0,808	0,416	-0,879	0,441				
	Ulna	Distal end	-2,960	0,003	-0,447	0,676	-0,780	0,561	-0,637	0,610	-2,583	0,008	-1,859	0,069	-1,059	0,340	-1,709	0,115
Hip	Coxal	*Acetabulum*	-1,036	0,300	-1,661	0,097	-1,397	0,157			-0,128	0,841	-0,334	0,744	-1,441	0,161		
	Femur	Proximal end	-2,167	0,026	-0,109	0,925	-0,522	0,614			-1,905	0,062	-0,978	0,336	-0,772	0,461		
Knee	Femur	Distal end	-2,015	0,050	-0,965	0,334	-0,588	0,575	-1,585	0,128	-1,853	0,053	-1,037	0,309	-0,658	0,570	-1,613	0,170
	Tibia	Proximal end	-0,194	0,895	-0,098	0,975	-1,149	0,274			-2,104	0,036	-1,105	0,347	-1,302	0,209		
	Patella		-2,144	0,033	-0,279	0,795	-0,628	0,564	-1,283	0,219	-0,742	0,465	-0,147	0,931	-0,074	1,000	-0,743	0,506
Ankle	Tibia	Distal end	-2,365	0,018	-0,816	0,557					-3,436	0,001	-2,368	0,019				
	Fibula	Distal end									-0,600	0,680	-1,000	0,533				

Bold p-values represent statistically significant values (according to the Monte Carlo significance test, 2-tailed).

Table 7 - Descriptive statistics of age according to degrees/categories of DBC: shoulder joint.

	Glenoid cavity										Humerus proximal end									
	Left	Marginal lipping				Right	Marginal lipping				Left	Marginal lipping				Right	Marginal lipping			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	224	20	37.97	83	14.299	228	20	38.2	83	14.01	338	20	45.03	88	17.322	315	20	43.07	87	16.37
Barely discernible	201	25	56.62	90	14.26	187	20	56.57	95	14.98	169	30	61.69	93	14.503	201	24	62.32	93	14.12
Sharp ridge	150	38	69.02	98	12.317	148	20	68.36	98	12.54	58	42	70.95	98	13.195	48	50	72.17	95	11.06
Extensive spicule	11	42	73.36	86	12.871	19	49	70.42	93	12.55	9	63	76	87	8.261	13	52	73.69	98	13.68

	Left	Porosity				Right	Porosity				Left	Porosity				Right	Porosity			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	510	20	51.27	98	18.415	526	20	51.71	98	18.44	528	20	51.66	98	18.731	542	20	51.73	95	18.44
Pinpoint	51	26	59.25	89	16.599	41	23	61.41	89	19.94	41	27	64.1	89	14.861	30	32	67.2	89	16.39
Coalescent	3	67	79	91	12	7	53	70.57	85	11.21	2	68	77	86	12.728	1	63	-	-	-
Both pinpoint and coalescent	22	25	74.45	95	14.543	8	25	66.73	87	19.32	8	64	77.38	87	8.245	5	75	85.2	98	8.408

	Left	Osteophytes				Right	Osteophytes				Left	Osteophytes				Right	Osteophytes			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	539	20	51.63	98	18.465	542	20	51.46	98	18.53	551	20	52	98	18.661	556	20	51.92	95	18.46
Barely discernible	10	47	66.5	89	16.202	13	50	71.38	89	10.67	11	42	69.18	84	13.739	10	50	74.7	98	14.46
Clearly present	37	31	69.03	95	15.509	27	46	71.19	95	11.69	17	56	74.35	87	10.198	12	63	77.67	87	7.632

	Left	Eburnation				Right	Eburnation				Left	Eburnation				Right	Eburnation			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	582	20	52.79	98	18.711	579	20	52.7	98	18.76	573	20	52.71	98	18.783	573	20	52.59	98	18.69
Barely discernible	1	84	-	-	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polish only	-	-	-	-	-	1	63	-	-	.	1	87	-	-	.	1	-	84	-	-
Polish with groove (s)	3	68	80	87	10.44	2	80	82	84	2.828	5	64	76.8	87	10.281	4	75	81.5	87	5.196

N – total number of observations; Min – minimum age; Mean – average age; Max – maximum age; s.d. – standard deviation.

Table 8 - Descriptive statistics of age according to degrees/categories of DBC: acromioclavicular joint

	Scapula: acromion articular surface										Clavicle: scromion articular surface									
	Left Marginal lipping					Right Marginal lipping					Left Marginal lipping					Right Marginal lipping				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	224	20	37.97	83	14.30	316	20	46.845	89	16.63	338	20	48.90	98	17.20	341	20	48.37	88	17.36
Barely discernible	201	25	56.62	90	14.26	98	37	63.827	95	13.47	81	28	66.889	95	14.25	84	37	64.23	95	13.57
Sharp ridge	150	38	69.02	98	12.32	58	38	68.879	98	13.73	46	47	69.457	93	13.60	38	47	71.82	98	11.91
Extensive spicule	11	42	73.36	86	12.87	15	50	70.60	93	12.26	4	70	74.75	78	3.95	12	50	67.42	93	13.47

	Left Porosity					Right Porosity					Left Porosity					Right Porosity				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	510	20	51.27	98	18.42	321	20	46.735	89	16.45	223	20	43.35	82	15.65	211	20	41.76	89	15.50
Pinpoint	51	26	59.25	89	16.60	47	41	67.064	89	12.70	81	30	61.77	98	16.44	84	24	58.94	95	15.14
Coalescent	3	67	79.00	91	12.00	6	33	60.33	86	22.11	8	52	71.75	89	14.84	10	30	60.50	82	16.04
Both pinpoint and coalescent	22	25	74.45	95	14.54	113	38	67.22	98	12.94	158	30	64.73	95	14.14	171	30	64.99	98	13.78

	Left Osteophytes					Right Osteophytes					Left Osteophytes					Right Osteophytes				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	539	20	51.63	98	18.46	480	20	53.425	98	18.18	457	20	53.768	98	18.46	460	20	52.87	98	18.08
Barely discernible	10	47	66.50	89	16.20	6	53	67.17	87	11.21	8	48	65.25	80	9.91	8	51	69.25	95	13.56
Clearly present	37	31	69.03	95	15.51	1	65	-	-	-	5	63	75.40	87	9.63	8	56	76.13	89	12.60

	Left Eburnation					Right Eburnation					Left Eburnation					Right Eburnation				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	582	20	52.79	98	18.71	467	20	53.06	95	18.12	458	20	53.85	98	18.50	458	20	52.976	95	18.21
Barely discernible	1	84	-	-	-	7	49	73.00	98	15.71	5	65	70.00	84	7.97	6	65	78.1667	98	11.48
Polish only	3	68	80	87	10.44	13	50	63.08	93	12.08	-	-	-	-	-	-	-	-	-	-
Polish with groove (s)	-	-	-	-	-	-	-	-	-	-	7	54	65.43	85	12.45	12	50	62.4167	93	12.37

N – total number of observations; Min – minimum age; Mean – average age; Max – maximum age; s.d. – standard deviation

Table 9 - Descriptive statistics of age according to degrees/categories of DBC: elbow joint.

Humerus distal end

	Left	Marginal lipping				Right	Marginal lipping			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	377	20	47.24	90	17.99	335	20	45.81	90	17.93
Barely discernible	144	23	62.35	95	15.32	191	30	61.99	95	14.40
Sharp ridge	36	40	71.25	98	13.64	36	49	70.67	98	12.96
Extensive spicule	8	51	64.25	80	11.54	6	53	63.50	80	11.47

	Left	Porosity				Right	Porosity			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	489	20	50.69	95	18.33	490	20	50.45	95	18.16
Pinpoint	48	23	66.00	89	15.91	51	32	67.84	93	14.03
Coalescent	9	32	57.78	82	18.85	10	33	64.80	83	15.50
Both pinpoint and coalescent	30	39	69.43	98	15.25	24	52	71.38	98	11.78

	Left	Osteophytes				Right	Osteophytes			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	516	20	51.2	95	18.5	505	20	50.8	95	18.1
Barely discernible	26	39	65.6	84	13.7	21	32	65.2	86	14.9
Clearly present	34	47	72.1	98	13.0	49	46	71.7	98	12.5

	Left	Eburnation				Right	Eburnation			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	557	20	52.4	95	18.7	562	20	52.6	98	18.5
Barely discernible	2	63	67.5	72	6.4	2	56	66.0	76	14.1
Polish only	4	58	64.5	72	5.8	6	63	76.3	88	10.9
Polish with groove (s)	13	50	74.9	98	14.2	5	57	79.0	91	12.9

Radius proximal end

	Left	Marginal lipping				Right	Marginal lipping			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	459	20	50.37	95	18.64	440	20	49.63	98	18.22
Barely discernible	55	27	61.89	87	14.26	60	38	67.37	91	12.49
Sharp ridge	25	38	68.68	98	15.31	18	46	66.72	93	13.42
Extensive spicule	10	51	72.10	83	10.01	16	53	71.81	88	12.45

	Left	Porosity				Right	Porosity			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	531	20	51.15	98	18.35	516	20	51.21	98	18.38
Pinpoint	29	27	70.93	87	13.32	25	44	71.44	89	12.62
Coalescent	4	63	79.25	88	11.82	3	76	78.00	80	2.00
Both pinpoint and coalescent	9	63	76.67	84	6.63	13	52	74.85	88	10.06

	Left	Osteophytes				Right	Osteophytes			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	539	20	51.6	95	18.6	517	20	51.37	98	18.58
Barely discernible	13	42	68.7	84	13.2	13	47	70.31	84	10.27
Clearly present	21	30	71.3	98	14.5	27	47	72.07	89	10.37

	Left	Eburnation				Right	Eburnation			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	556	20	52.2	98	18.7	544	20	52.22	98	18.58
Barely discernible	1	50	50.0	50	.	3	62	79.33	88	15.01
Polish only	5	72	80.4	88	7.3	4	63	76.0	91	11.52
Polish with groove (s)	11	50	68.6	85	13.1	6	57	78.33	86	10.71

Ulna proximal end

	Left	Marginal lipping				Right	Marginal lipping			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	324	20	44.74	95	18.1	290	20	42.44	87	16.4
Barely discernible	163	27	60.64	91	14.0	180	27	62.34	95	14.6
Sharp ridge	82	33	68.32	98	13.0	100	34	66.19	98	13.6
Extensive spicule	7	51	64.86	78	10.1	10	56	71.6	88	13.1

	Left	Porosity				Right	Porosity			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	542	20	51.66	95	18.6	541	20	51.77	95	18.5
Pinpoint	21	37	67.76	91	14.5	24	46	70.5	91	11.9
Coalescent	12	46	69.92	85	12.8	11	59	75.36	98	11.5
Both pinpoint and coalescent	9	52	66.67	98	14.2	7	52	71.29	83	10.4

	Left	Osteophytes				Right	Osteophytes			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	563	20	52.27	98	18.7	563	20	52.63	98	18.6
Barely discernible	4	50	68.75	93	21.2	10	47	72.1	91	14.9
Clearly present	17	47	68.12	91	13.4	10	39	67.4	89	14.7

	Left	Eburnation				Right	Eburnation			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	581	20	52.7	98	18.7	582	20	53.2	98	18.8
Barely discernible	-	-	-	-	-	-	-	-	-	-
Polish only	-	-	-	-	-	1	65	-	-	-
Polish with groove (s)	3	74	80.67	85	5.9	-	-	-	-	-

N – total number of observations; Min – minimum age; Mean – average age; Max – maximum age; s.d. – standard deviation.

Table 10 - Descriptive statistics of age according to degrees/categories of DBC: wrist joint.

	Radius distal end: Left Marginal lipping					Radius distal end: Right Marginal lipping					Ulna distal end: Left Marginal lipping					Ulna distal end: Right Marginal lipping				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	410	20	47.74	95	17.94	407	20	47.76	89	17.87	449	20	49.34	93	17.85	412	20	48.18	93	17.88
Barely discernible	132	24	63.60	98	15.25	134	24	63.17	93	14.45	51	32	67.94	95	11.90	90	27	65.92	95	13.20
Sharp ridge	22	31	71.05	91	14.80	24	47	73.29	95	12.34	27	47	68.67	91	11.54	28	32	62.79	82	12.27
Extensive spicule	6	44	64.50	84	16.18	5	50	71.20	81	12.32	6	50	74.33	89	13.60	9	50	76.00	88	12.24

	Radius distal end: Left Porosity					Radius distal end: Right Porosity					Ulna distal end: Left Porosity					Ulna distal end: Right Porosity				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	560	20	52.16	98	18.74	557	20	52.25	95	18.52	505	20	51.60	95	18.31	514	20	51.32	95	18.12
Pinpoint	11	38	64.91	88	17.68	10	27	67.20	87	17.73	16	27	63.38	87	15.34	19	43	69.89	91	13.03
Coalescent	2	74	77.00	80	4.24	-	-	-	-	-	3	54	60.00	67	6.56	3	52	68.67	84	16.04
Both pinpoint and coalescent	2	78	81.00	84	4.24	5	60	77.60	86	10.33	10	47	72.10	89	14.31	5	75	82.60	88	5.90

	Radius distal end: Left Osteophytes					Radius distal end: Right Osteophytes					Ulna distal end: Left Osteophytes					Ulna distal end: Right Osteophytes				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	569	20	52.32	98	18.74	567	20	52.60	95	18.67	519	20	51.92	95	18.34	519	20	51.56	95	18.22
Barely discernible	3	65	80.33	88	13.28	1	73	-	-	-	4	54	65.75	84	13.33	12	50	71.92	89	12.37
Clearly present	3	70	76.33	84	7.10	4	47	67.25	81	14.84	11	46	69.27	89	14.35	10	43	70.00	87	16.08

	Radius distal end: Left Eburnation					Radius distal end: Right Eburnation					Ulna distal end: Left Eburnation					Ulna distal end: Right Eburnation				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	570	20	52.51	98	18.86	565	20	52.50	95	18.64	523	20	51.90	95	18.18	527	20	51.83	95	18.32
Barely discernible	-	-	-	-	-	-	-	-	-	-	2	50	58.00	66	11.31	2	88	88.00	88	0.00
Polish only	-	-	-	-	-	3	56	69.67	78	11.93	4	65	83.00	91	12.08	5	50	63.60	78	12.97
Polish with groove (s)	5	44	62.40	84	17.16	4	63	73.75	84	9.18	5	57	76.00	89	14.87	7	63	73.57	84	7.85

N - total number of observations; Min - minimum age; Mean - average age; Max - maximum age; s.d. - standard deviation.

Table 11 - Descriptive statistics of age according to degrees/categories of DBC: hip joint.

Femur proximal end

	Left Marginal lipping					Right Marginal lipping				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	263	20	41.50	95	16.16	242	20	40.70	89	16.29
Barely discernible	233	20	58.93	98	16.23	239	25	57.62	93	15.82
Sharp ridge	85	41	68.54	93	12.92	98	46	67.29	98	12.49
Extensive spicule	8	39	69.13	79	13.62	11	63	76.36	95	12.12

	Left Porosity					Right Porosity				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	480	20	50.28	98	18.66	477	20	50.32	98	18.22
Pinpoint	82	25	62.74	89	16.34	82	23	61.29	95	18.19
Coalescent	4	37	46.25	56	10.15	2	37	46.50	56	13.44
Both pinpoint and coalescent	29	29	67.14	90	14.86	35	23	64.60	91	17.96

	Left Osteophytes					Right Osteophytes				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	503	20	50.41	98	18.72	499	20	50.06	98	18.49
Barely discernible	28	30	65.89	91	15.48	26	25	63.65	88	14.13
Clearly present	64	34	65.81	90	13.47	71	34	66.87	95	13.98

	Left Eburnation					Right Eburnation				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	592	20	52.66	98	18.85	589	20	52.39	98	18.68
Barely discernible	1	69	-	-	-	-	-	-	-	-
Polish only	-	-	-	-	-	2	64	67.00	70	4.24
Polish with groove (s)	2	79	84.50	90	7.78	5	64	78.40	91	13.28

Acetabulum

	Left Marginal lipping					Right Marginal lipping				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	85	20	30.69	74	10.21	76	20	29.51	74	10.01
Barely discernible	187	20	45.19	89	15.29	194	20	45.34	89	15.55
Sharp ridge	275	25	62.42	98	14.47	284	21	61.85	98	14.48
Extensive spicule	44	37	70.32	93	13.24	42	37	71.40	95	13.15

	Left Porosity					Right Porosity				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	422	20	48.43	98	18.03	411	20	47.56	98	17.48
Pinpoint	69	31	59.72	89	14.76	75	30	61.27	95	15.23
Coalescent	21	28	65.00	84	16.52	18	30	63.78	85	16.58
Both pinpoint and coalescent	79	30	68.29	91	15.14	91	23	69.11	91	14.67

	Left Osteophytes					Right Osteophytes				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	534	20	51.28	98	18.37	525	20	50.71	98	18.34
Barely discernible	11	47	62.82	85	13.96	14	47	68.00	88	12.99
Clearly present	46	27	70.57	95	14.85	57	39	70.68	95	12.11

	Left Eburnation					Right Eburnation				
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	590	20	52.93	98	18.75	587	20	52.72	98	18.74
Barely discernible	-	-	-	-	-	-	-	-	-	-
Polish only	1	90	-	-	-	4	60	65.50	70	4.44
Polish with groove (s)	-	-	-	-	-	5	64	78.40	91	13.28

N - total number of observations; Min - minimum age; Mean - average age; Max - maximum age; s.d. - standard deviation.

Table 12 - Descriptive statistics of age according to degrees/categories of DBC: knee joint.

Femur distal end

Left	Left N	Min.	Mean	Max	s.d.	Right N	Min.	Mean	Max	s.d.
Marginal lipping										
Absent	299	20	43.98	95	17.49	274	20	43.30	95	17.77
Barely discernible	193	20	58.03	98	16.19	205	20	56.83	89	15.92
Sharp ridge	79	32	67.16	91	13.85	85	34	65.45	98	13.52
Extensive spicule	24	52	71.75	93	11.37	31	46	74.10	93	10.58
Porosity										
Absent	507	20	49.93	89	18.14	506	20	49.82	98	18.24
Pinpoint	58	30	64.98	95	15.74	60	30	66.73	95	14.21
Coalescent	2	48	73.00	98	35.36	4	52	67.00	79	11.52
Both pinpoint and coalescent	29	52	75.59	91	9.43	28	55	74.25	93	10.35
Osteophytes										
Absent	501	20	49.42	95	18.08	495	20	49.27	98	17.98
Barely discernible	19	40	62.79	84	13.46	21	41	63.62	84	13.05
Clearly present	76	46	72.00	98	11.90	82	32	71.18	95	12.92
Eburnation										
Absent	577	20	52.02	98	18.71	566	20	51.52	98	18.52
Barely discernible	3	63	72.33	80	8.62	7	65	76.57	91	8.85
Polish only	3	48	71.67	84	20.50	3	68	73.67	84	8.96
Polish with groove (s)	13	47	75.00	89	10.92	22	53	74.73	87	9.59

Tibia proximal end

Left	Left N	Min.	Mean	Max	s.d.	Right N	Min.	Mean	Max	s.d.
Marginal lipping										
Absent	357	20	44.74	89	17.18	356	20	45.46	98	18.13
Barely discernible	130	20	62.18	98	14.98	126	20	59.50	95	14.65
Sharp ridge	95	32	67.76	93	13.12	88	34	67.41	93	12.71
Extensive spicule	6	52	72.17	89	13.73	20	47	73.40	91	10.14
Porosity										
Absent	556	20	51.42	98	18.64	556	20	51.52	98	18.73
Pinpoint	31	50	71.97	89	10.12	33	37	69.33	89	13.02
Coalescent	1	83	-	-	-	1	62	-	-	-
Both pinpoint and coalescent	7	52	71.43	89	13.71	8	55	71.00	83	10.90
Osteophytes										
Absent	565	20	51.74	98	18.68	560	20	51.60	98	18.64
Barely discernible	12	40	69.50	85	12.94	13	50	69.77	85	10.50
Clearly present	18	52	74.33	90	10.33	25	37	70.52	91	15.36
Eburnation										
Absent	589	20	[illegible]	98	18.80	586	20	52.30	98	18.77
Barely discernible	1	74		-	-	-	-	-	-	-
Polish only	1	83	-	-	-	1	62	-	-	-
Polish with groove (s)	4	68	81.75	89	9.50	11	65	77.82	87	7.68

Patella

Left	Left N	Min.	Mean	Max	s.d.	Right N	Min.	Mean	Max	s.d.
Marginal lipping										
Absent	249	20	41.43	89	16.73	243	20	40.59	89	16.80
Barely discernible	178	20	57.62	95	15.10	170	20	56.78	95	14.02
Sharp ridge	101	33	67.21	98	13.59	101	33	67.81	98	13.06
Extensive spicule	11	54	72.82	93	12.93	16	47	72.06	84	9.88
Porosity										
Absent	470	20	49.55	98	18.12	464	20	49.36	95	18.10
Pinpoint	37	42	68.62	93	14.05	36	44	69.53	90	13.50
Coalescent	8	57	68.50	85	10.85	10	57	71.50	84	10.45
Both pinpoint and coalescent	28	52	73.68	89	10.33	21	45	69.76	98	13.36
Osteophytes										
Absent	482	20	49.80	95	18.04	472	20	49.59	95	18.11
Barely discernible	6	58	71.67	85	8.94	14	46	65.93	85	13.79
Clearly present	55	45	72.82	98	12.03	45	45	72.36	98	11.95
Eburnation										
Absent	530	20	52.00	98	18.87	512	20	51.16	98	18.62
Barely discernible	2	47	55.00	63	11.31	2	70	76.50	83	9.19
Polish only	3	48	59.00	67	9.85	2	76	79.00	82	4.24
Polish with groove (s)	8	64	74.38	84	7.05	15	53	71.87	84	9.29

N – total number of observations; Min – minimum age; Mean – average age; Max – maximum age; s.d. – standard deviation.

Table 13 - Descriptive statistics of age according to degrees/categories of DBC: ankle joint.

Tibia distal end

	Left	Marginal lipping				Right	Marginal lipping			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	423	20	48.96	98	19.15	423	20	48.96	98	19.15
Barely discernible	158	20	61.74	93	14.61	158	20	61.74	93	14.61
Sharp ridge	15	34	66.47	82	11.54	15	34	66.47	82	11.54
Extensive spicule										

	Left	Porosity				Right	Porosity			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	591	20	52.51	98	18.80	581	20	52.54	98	18.90
Pinpoint	6	60	73.33	89	9.75	9	28	57.89	89	20.08
Coalescent	-	-	-	-	-	2	59	63.50	68	6.36
Both pinpoint and coalescent	2	75	82.00	89	9.90	4	60	65.00	72	5.10

	Left	Osteophytes				Right	Osteophytes			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	594	20	52.68	98	18.86	582	20	52.55	98	18.95
Barely discernible	1	70	-	-	.	5	50	68.00	88	13.77
Clearly present	4	47	69.50	87	17.29	9	42	56.56	76	11.36

	Left	Eburnation				Right	Eburnation			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	597	20	52.72	98	18.84	-	-	-	-	-
Barely discernible	-	-	-	-	-	-	-	-	-	-
Polish only	-	-	-	-	-	-	-	-	-	-
Polish with groove (s)	2	75	82.00	89	9.90	-	-	-	-	-

Fibula distal end

	Left	Marginal lipping				Right	Marginal lipping			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	550	20	51.89	98	18.88	552	20	51.79	98	18.70
Barely discernible	31	47	64.74	88	11.55	27	47	67.59	84	12.47
Sharp ridge	1	64	-	-	-	2	62	63.00	64	1.414
Extensive spicule	-	-	-	-	-	-	-	-	-	-

	Left	Porosity				Right	Porosity			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	578	20	52.50	98	18.77	576	20	52.32	98	18.72
Pinpoint	3	50	63.33	78	14.05	4	54	67.50	78	11.48
Coalescent	1	76	-	-	.	2	76	79.00	82	4.243
Both pinpoint and coalescent	-	-	-	-	-	-	-	-	-	-

	Left	Osteophytes				Right	Osteophytes			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	579	20	52.46	98	18.71	578	20	52.34	98	18.68
Barely discernible	1	74	-	-	.	3	68	75.33	82	7.02
Clearly present	-	-	-	-	-	1	87	-	-	-

	Left	Eburnation				Right	Eburnation			
Left	N	Min.	Mean	Max.	s.d.	N	Min.	Mean	Max.	s.d.
Absent	-	-	-	-	-	-	-	-	-	-
Barely discernible	-	-	-	-	-	-	-	-	-	-
Polish only	-	-	-	-	-	-	-	-	-	-
Polish with groove (s)	-	-	-	-	-	-	-	-	-	-

N - total number of observations; Min - minimum age; Mean - average age; Max - maximum age; s.d. - standard deviation.

Table 14 – Descriptive statistics of age at death according to OA analysis (total sample).

		Left						Right			
Shoulder1	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**	**Shoulder1**	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**
absent	518	20	50.24	98	18.13	absent	533	20	50.64	95	18.26
present	78	31	70.68	95	13.38	present	59	46	72.20	98	11.03
Total	596	20	52.92	98	18.88	Total	592	20	52.79	98	18.81

Shoulder2	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**	**Shoulder2**	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**
absent	462	20	48.16	98	17.62	absent	471	20	48.56	90	17.87
present	134	31	69.32	95	12.98	present	123	38	69.48	98	12.28
Total	596	20	52.92	98	18.88	Total	594	20	52.89	98	18.87

Elbow	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**	**Elbow**	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**
absent	507	20	50.33	95	18.35	absent	517	20	50.38	95	18.23
present	85	39	69.05	98	13.16	present	76	46	71.08	98	11.36
Total	592	20	53.02	98	18.87	Total	593	20	53.04	98	18.82

Wrist	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**	**Wrist**	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**
absent	553	20	52.03	98	18.76	absent	556	20	51.99	95	18.58
present	30	44	66.70	91	13.93	present	24	46	68.88	88	13.38
Total	583	20	52.79	98	18.82	Total	580	20	52.69	95	18.69

Hip	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**	**Hip**	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**
absent	419	20	46.71	98	17.50	absent	414	20	46.32	98	17.37
present	180	30	67.23	95	13.37	present	187	25	67.40	95	13.02
Total	599	20	52.88	98	18.87	Total	601	20	52.88	98	18.85

Knee	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**	**Knee**	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**
absent	475	20	48.32	95	17.70	absent	475	20	48.48	89	17.78
present	127	32	69.76	98	12.45	present	127	37	69.20	98	13.09
Total	602	20	52.84	98	18.87	Total	602	20	52.85	98	18.89

Ankle	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**	**Ankle**	**N**	**Minimum**	**Mean**	**Maximum**	**S.D.**
absent	597	20	52.69	98	18.82	absent	588	20	52.49	98	18.90
present	4	70	78.00	89	8.04	present	10	50	65.50	82	9.94
Total	601	20	52.86	98	18.88	Total	598	20	52.71	98	18.86

S.D. - Standard Deviation

Shoulder[1] - Includes the follwing articular surfaces: glenoid cavity and humerus proximal end (head).

Shoulder[2] - Includes the following articular surfaces: acromion articular surface of the clavicle and sacpula, glenoid cavity and humerus proximal end (head).

1.3 *Appendix_MSM*

Table 15 - Jonckheere-Terpstra test results: differences between mean ages per groups of MSM degrees.

Bone	N.	Enthesis	Left side J	Left side p	Left side Group mean ≠	Right side J	Right side p	Right side Group mean ≠
Clavicle	1	**Acromial extremity** – *Trapezius muscle*	**62357,0**	<0.001	**Situation 1**	54901,5	**<0.001**	Situation 4
	2	**Acromial extremity** – *Deltoideus muscle*	**77057,0**	**<0.001**	**Situation 2**	69993,0	**<0.001**	**Situation 5**
	3	Impression for costoclavicular **ligament**	61849,5	**<0001**	**Situation 3**	36247,0	**0,307**	Situation 2
Scapula	**4**	**Corocoid process**	**48294,5**	<0.001	**Situation 6**	**48121,0**	**<0.01**	Situation 1
	5	**Acromion** - *Deltoideus muscle*	**34557,5**	**<0.001**	Situation 4	42562,0	**<0.001**	Situation 7
	6	**Acromion** – *Trapezius muscle*	**31801,0**	**<0.001**	**Situation 4**	36665,0	**<0.001**	**Situation 1**
Humerus	**7**	Surgical **neck**	**83000,0**	**<0.001**	Situation 8	83897,5	**<0.001**	Situation 8
	8	Greater tubercle	**39781,0**	**<0.001**	**Situation 6**	42669,5	**<0.001**	Situation 6
	9	**Lesser** tubercle	68168,5	<0.001	**Situation 3**	71783,5	<0001	Situation 3
	10	**Deltoid** tuberosity	62321,5	**<0.001**	Situation 4	70609,5	**<0.001**	**Situation 1**
	11	**Lateral epicondyle**	45828,5	<0.001	Situation 6	**55236,5**	**<0.001**	**Situation 6**
	12	**Medial epicondyle**	20857,0	**<0.001**	**Situation 6**	31975,5	**<0.001**	**Situation 6**
Radius	**13**	**Radial** tuberosity	83349,0	<0.001	Situation 3	84790,5	<0.001	**Situation 3**
	14	Inter-osseous border - *Pronator teres* insertion	65021,5	<0.001	Situation 2*	56515,5	**<0.001**	**Situation 4**
Ulna	**15**	Olecranon	**21283,0**	<0.001	Situation 6	**31351,0**	**<0.001**	Situation 6
	16	**Ulna** tuberosity	46182,0	**<0.001**	**Situation 7**	**57390,5**	**<0.001**	Situation 3

Bone	N.	Enthesis	Left side J	Left side p	Left side Group mean ≠	Right side J	Right side p	Right side Group mean ≠
Coxal	17	*Ischium* tuberosity	96951,5	**<0.001**	Situation 2	97262,0	**<0.001**	Situation 2
	18	Iliac crest	87024,0	**<0.001**	Situation 2	82329,5	<0.001	Situation 5
Femur	19	**Greater trochanter**	89495,5	<0.001	Situation 3	55300,5	0,586	Situation 9
	20	**Gluteal** tuberosity	93449,0	<0.001	Situation 2	94848,5	<0.001	Situation 2
	21	Linea aspera	89002,0	**<0.001**	Situation 3	85275,5	<0.001	Situation 8
	22	Medial **supracondylar line**	**21237,0**	**<0.001**	Situation 6	30028,0	**<0.001**	Situation 10
Tibia	**23**	Anterior tuberosity	67556,5	<0.001	**Situation 3**	65580,0	**<0.001**	**Situation 6**
	24	Soleal line	**77082,0**	<0.001	Situation 3	79870,5	**<0.001**	Situation 3
	25	**Fibular notch**	48308,0	<0.001	**Situation 2***	53629,0	**<0.001**	**Situation 2***
Calcaneus	26	Posterior **surface** of calcaneus	66893,5	<0.001	Situation 2	68561,0	<0.001	Situation 2
	27	Plantar **surface**	**57710,0**	**<0.001**	Situation 3	60025,5	<0.001	**Situation 5**
Patella	**28**	**Base** of anterior **surface**	71652,0	**<0.001**	Situation 7	**67211,0**	<0.001	Situation 5

p*) - two-tailed Monte Carlo significance test; * - group Strong **was** not included due to small number of cases **(one)**.

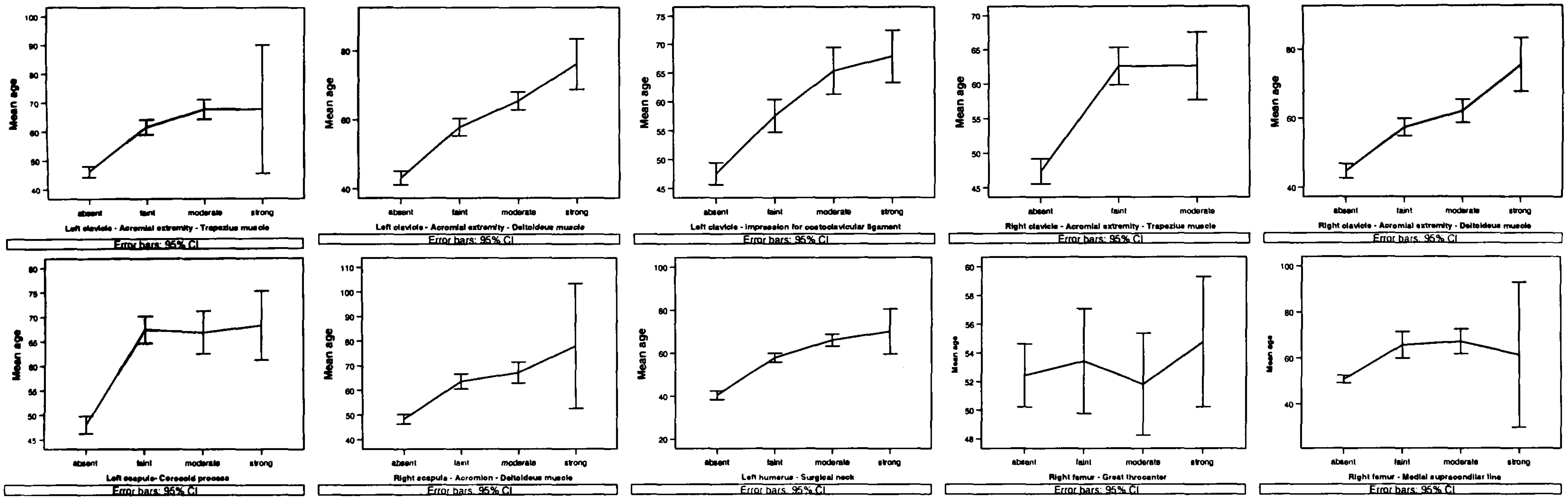

Figure 1 - Description of the different situations observed when analysing pairwise comparisons using the One-Way ANOVA statistical test. Graphs exemplify the ten situations found. They were ordered from left to right, top row first followed by bottom row. Special attention must be given to the confidence intervals, as in many cases they tend to overlap. This was particularly true in the case of lesions coded as Strong (grade 3). This group of lesion was also the one with the lowest frequency observed, this may explain the behaviour expressed by the group's confidence interval. Several homogenous groups, that did not differ between themselves, were found. They were mostly formed by the groups Moderate and Strong, or Faint and Moderate.

Situation 1 – the groups Absent, Faint and Moderate significantly differ from each other, but not from the Strong; **Situation 2** – all groups differ amongst themselves; **Situation 3** – there is one homogenous group that differs from the others but not within [Moderate=Strong], Absent and Faint also differ from each other; **Situation 4** – group Strong is not represented since it was composed of only one case; regarding the remaining groups, there is one homogenous group that differ from Absent but not within, [Moderate=Faint]; **Situation 5** – the group Absent differs from all remaining groups, Faint also differs from Strong, and homogenous groups were found between [Faint=Moderate] and [Moderate=Strong]; **Situation 6** - the group Absent differs from all remaining groups; one homogenous group was found [Faint=Moderate=Strong]; **Situation 7** - the group Absent and Strong differ from all remaining groups; one homogenous group was found [Faint=Moderate]; **Situation 8** - the group Absent differs from all remaining groups; the groups Faint and Moderate differ from one another but not from Strong; **Situation 9** – none of the groups differ amongst them; **Situation 10** – the group Strong does not differ from the remaining ones; Absent differs from Moderate and Faint that do not differ from one another.

The above post-hoc pairwise comparison revealed that, although there were significant differences between mean ages of groups, there are at least ten situations which were recurrent as illustrated in Figure 1. In most cases the mean age of the group without lesions (absence) was lower than the mean age found in the remaining groups; moderate and strong MSM lesions displayed a similar mean age value, and the mean age of faint MSM group could either differ from all remaining groups, or have similar mean value as the one found in moderate, or strong MSM group.

1.4 Appendix_ Grouped_Variables

1.4.1 SumDBC and sumMSM variables per joint

1.1.1.1 Spearman's rank correlation values

SumDBC and SumMSM correlations per joints, revealed to be all statistical significant according to the Spearman's rank correlation (p<0.001) (Table 16).

Table 16 – SumDBC and SumMSM correlation values according to joint.

		Left SumDBC and SumMSM Spearman's rho correlation values					Right SumDBC and SumMSM Spearman's rho correlation values				
Joint	**Spearman's rho**	**Shoulder**	**Elbow**	**Hip**	**Knee**	**Ankle**	**Shoulder**	**Elbow**	**Hip**	**Knee**	**Ankle**
Shoulder	r	0,669	0,592	0,691	0,474	0,424	0,640	0,620	0,616	0,457	0,397
	P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	N	599	596	599	599	595	597	593	597	597	592
Elbow	r	0,541	0,515	0,561	0,344	0,318	0,569	0,623	0,517	0,396	0,416
	P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	N	591	592	592	592	589	593	592	593	593	589
Hip	r	0,591	0,492	0,644	0,449	0,320	0,569	0,554	0,575	0,497	0,370
	P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	N	598	595	599	599	596	601	596	601	601	596
Knee	r	0,566	0,493	0,648	0,488	0,388	0,533	0,549	0,567	0,477	0,396
	P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	N	601	598	602	602	598	602	597	602	602	597
Ankle	r	0,395	0,369	0,447	0,384	0,340	0,382	0,338	0,371	0,347	0,323
	P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	N	601	598	602	602	598	598	593	598	598	593

r - Spearman's correlation values; P - correlation were all significant at the 0.01 level (2-tailed); N - total number of observations

1.1.1.2 Descriptive statistics

Descriptive statistics of the Sum variables per joint according to sex, as well as total sample.

Table 17 – Descriptive statistics of SumDBC, per joint, and according to sex-subsamples.

	Female			Male			Total sample		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
SumDBC_shoulder_left	302	4.72	5.51	297	3.82	4.16	599	4.27	4.90
SumDBC_elbow_left	297	2.67	4.44	295	1.73	2.82	592	2.20	3.75
SumDBC_wrist_left	290	0.80	2.04	293	0.80	1.63	583	0.80	1.84
SumDBC_hip_left	300	3.48	2.92	299	3.49	3.18	599	3.49	3.05
SumDBC_knee_left	302	4.05	5.16	300	2.40	3.54	602	3.23	4.50
SumDBC_ankle_left	303	0.57	0.96	299	0.48	0.85	602	0.52	0.91
SumDBC_shoulder_right	300	4.61	5.40	297	4.48	4.86	597	4.55	5.13
SumDBC_elbow_right	296	2.75	4.16	297	1.94	3.02	593	2.35	3.66
SumDBC_wrist_right	290	0.90	2.09	290	0.92	1.97	580	0.91	2.03
SumDBC_hip_right	302	3.79	3.56	299	3.75	3.27	601	3.77	3.42
SumDBC_knee_right	302	4.34	5.47	300	2.62	4.17	602	3.48	4.93
SumDBC_ankle_rigth	299	0.48	0.83	299	0.64	1.03	598	0.56	0.94

Table 18- Descriptive statistics of SumMSM, per joint and according to sex-subsamples.

	Female			Male			Total sample		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
SumMSM_shoulder_left	303	4.46	4.66	299	4.24	4.36	602	4.35	4.51
SumMSM_elbow_left	302	1.86	2.17	297	1.78	2.10	599	1.82	2.13
SumMSM_hip_left	303	4.78	3.64	300	3.72	3.47	603	4.25	3.59
SumMSM_knee_left	303	2.63	2.23	300	2.95	2.40	603	2.79	2.32
SumMSM_ankle_left	303	2.31	2.16	296	1.88	1.98	599	2.10	2.08
SumMSM_shoulder_right	303	4.47	4.38	300	4.48	4.00	603	4.47	4.19
SumMSM_elbow_right	300	2.45	2.67	298	2.13	2.50	598	2.29	2.59
SumMSM_hip_righ	303	4.42	2.96	300	3.78	2.80	603	4.10	2.90
SumMSM_knee_right	303	2.65	2.27	300	2.91	2.47	603	2.78	2.37
SumMSM_ankle_right	301	2.40	2.14	297	1.91	1.88	598	2.16	2.03

1.1.1.3 Hierarchical regression test results

Hierarchical regression was performed in the sum variables where significant differences were found between male and female individuals after using Mann-Whitney test. The method Enter was used in the analysis, therefore although two models are presented, each correspond to a specific analysis. In the first model only sex was used as predictor of the *Sum* variables; in the second model both sex and age were entered as predictors for the outcome of the variables under analysis.

The results proven that, with the exception of the knee joints (Tables 20 and 21), in all remaining cases (Tables 19, 22 to 25) only age was a significant predictor in the outcome of degenerative lesion on the joints, and lesions on the muscular insertion sites analysed. In the knee joints both sex and age were of significant importance in the outcome of lesions.

Table 19 – Regression model summary and table of regression coefficients of SumDBC_Right_Elbow.

Model	R	R Square	Adjusted R Square
1) Sex	0,111	0,012	0,011
2) Sex and Age	0,506	0,256	0,254

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2,753	0,211		13,019	<0.001	2,338	3,169
	sex	-0,814	0,299	-0,111	-2,724	0,007	-1,401	-0,227
2	(Constant)	-2,719	0,434		-6,265	<0.001	-3,571	-1,867
	sex	-0,203	0,263	-0,028	-0,772	0,440	-0,720	0,314
	age	0,097	0,007	0,501	13,917	<0.001	0,084	0,111

Table 20 - Regression model summary and table of regression coefficients of SumDBC_Left_Knee.

Model	R	R Square	Adjusted R Square
1) Sex	0,184	0,034	0,032
2) Sex and Age	0,561	0,315	0,313

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4,053	0,255		15,904	<0.001	3,553	4,553
	sex	-1,653	0,361	-0,184	-4,579	<0.001	-2,362	-0,944
2	(Constant)	-3,110	0,505		-6,162	<0.001	-4,101	-2,119
	sex	-0,871	0,308	-0,097	-2,827	0,005	-1,477	-0,266
	age	0,128	0,008	0,537	15,684	<0.001	0,112	0,144

Table 21 - Regression model summary and table of regression coefficients of SumDBC_Right_Knee.

Model	R	R Square	Adjusted R Square
1) Sex	0,175	0,031	0,029
2) Sex and Age	0,540	0,291	0,289

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4,344	0,280		15.528	<0.001	3,795	4,894
	sex	-1,728	0,396	-0,175	-4,359	<0.001	-2,506	-0,949
2	(Constant)	-3,213	0,563		-5,712	<0.001	-4,318	-2,108
	sex	-0,900	0,344	-0,091	-2,618	0,009	-1,575	-0,225
	age	0,135	0,009	0,517	14,847	<0.001	0,117	0,153

Table 22 - Regression model summary and table of regression coefficients of SumMSM_Left_Hip.

Model	R	R Square	Adjusted R Square
1) Sex	0,148	0,022	0,020
2) Sex and Age	0,709	0,503	0,501

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4,776	0,204		23,377	<0.001	4,374	5,177
	sex	-1,059	0,290	-0.148	-3,656	<0.001	-1,628	-0,490
2	(Constant)	-2,708	0,343		-7,895	<0.001	-3,381	-2,034
	sex	-0,233	0,209	-0,032	-1,112	0,267	-0,644	0,179
	age	0,134	0,006	0,703	24,103	<0.001	0,123	0,145

Table 23 - Regression model summary and table of regression coefficients of SumMSM_Right_Hip.

Model	R	R Square	Adjusted R Square
1) Sex	0,111	0,012	0,011
2) Sex and Age	0,628	0,395	0,393

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4,419	0,166		26,686	<0.001	4,094	4,744
	sex	-0,642	0,235	-0,111	-2,737	0,006	-1,104	-0,181
2	(Constant)	-0,963	0,305		-3,154	0,002	-1,563	-0,363
	sex	-0,048	0,186	-0,008	-0,259	0,795	-0,415	0,318
	age	0,096	0,005	0,627	19,472	<0.001	0,086	0,106

Table 24 - Regression model summary and table of regression coefficients of SumMSM_Left_Ankle.

Model	R	R Square	Adjusted R Square
1) Sex	0,103	0,011	0,009
2) Sex and Age	0,400	0,160	0,157

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2,310	0,119		19,406	<0.001	2,076	2,544
	sex	-0,428	0,169	-0,103	-2,530	0,012	-0,761	-0,096
2	(Constant)	-0,108	0,259		-0,415	0,678	-0,616	0,401
	sex	-0,161	0,158	-0,039	-1,019	0,309	-0,472	0,150
	age	0,043	0,004	0,392	10,303	<0.001	0,035	0,051

Table 25 - Regression model summary and table of regression coefficients of SumMSM_Right_Ankle.

Model	R	R Square	Adjusted R Square
1) Sex	0,122	0,015	0,013
2) Sex and Age	0,429	0,184	0,182

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2,402	0,116		20,677	<0.001	2,174	2,630
	sex	-0,493	0,165	-0,122	-2,990	0,003	-0,817	-0,169
2	(Constant)	-0,104	0,249		-0,418	0,676	-0,593	0,385
	sex	-0,223	0,152	-0,055	-1,466	0,143	-0,522	0,076
	age	0,045	0,004	0,417	11,125	<0.001	0,037	0,053

1.1.1.4 Kruskal-Wallis test results

Statistical significant difference between occupational groups and the mean values of SumDBC were found in almost all the variables with the exception of: left wrist ($p=0.695$) and right wrist ($p=0.796$). The significant values found in the left ankle ($p=0.054$), and right shoulder ($p=0.068$) were only marginally significant (Table 26).

Table 26 - Kruskal-Wallis test results: SumDBC mean difference per occupational groups.

SumDBC	Left						Right					
	Shoulder	Elbow	Wrist	Hip	Knee	Ankle	Shoulder	Elbow	Wrist	Hip	Knee	Ankle
H	16.718	12.923	3.930	19.429	27.031	12.084	11.741	14.511	3.168	14.722	32.129	11.257
df	6	6	6	6	6	6	6	6	6	6	6	6
Monte Carlo Sig. (2-tailed)	0.009	0.044	0.695	0.004	<0.001	0.054	0.068	0.023	0.796	0.022	<0.001	0.08

Statistical significant difference between occupational groups and the mean values of SumMSM were found in almost all the variables with the exception of: left elbow (p=0.130), right elbow (p=0.355) and right ankle (p=0.052), although in this last case the value p-value is on the threshold of being significant (Table 27). Descriptive statistics can be consulted in Table 28.

Table 27 - Kruskal-Wallis test results: SumMSM mean differences per occupational groups.

SumMSM	Left					Right				
	Shoulder	Elbow	Hip	Knee	Ankle	Shoulder	Elbow	Hip	Knee	Ankle
H	19.618	9.785	24.563	17.498	15.364	13.275	6.698	14.931	21.812	12.393
df	6	6	6	6	6	6	6	6	6	6
Monte Carlo Sig. (2-tailed)	0.002	0.130	<0.001	0.007	0.016	0.036	0.355	0.019	0.001	0.052

Table 28 - Descriptive statistics of SumDBC and SumMSM per occupational group.

	Government administration/Services			Commerce/Transport			Skilled workers/Artisans			Farmers/Servants			Unskilled workers			Army/Navy			Housewives		
	N	Mean	S.D.*	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
SumDBC shoulder_left	51	4.14	4.41	84	4.32	4.34	102	3.58	4.09	28	3.68	4.21	37	3.97	4.04	22	1.36	2.63	275	4.87	5.60
SumDBC elbow_left	50	2.08	3.04	83	1.89	2.88	102	1.37	1.96	28	1.82	3.84	37	2.11	3.08	22	1.41	4.09	270	2.75	4.53
SumDBC wrist_left	51	1.04	2.07	83	0.69	1.33	100	0.79	1.52	28	0.43	1.40	36	1.06	2.34	21	0.95	1.99	264	0.78	2.00
SumDBC hip left	52	3.50	2.93	84	4.14	3.49	102	3.19	3.16	28	2.07	2.16	37	3.70	2.91	23	2.43	3.04	273	3.60	2.94
SumDBC knee_left	52	3.17	3.31	85	2.73	3.77	102	2.48	4.21	28	1.71	3.29	37	1.95	2.66	23	1.35	2.12	275	4.16	5.22
SumDBC_ankle_left	52	0.56	0.75	85	0.61	0.91	101	0.37	0.91	28	0.68	1.42	37	0.30	0.57	23	0.35	0.65	276	0.58	0.92
SumDBC shoulder_right	51	4.59	4.85	83	5.08	5.09	102	3.93	4.42	28	3.32	5.07	37	5.70	6.08	23	2.39	3.07	273	4.76	5.40
SumDBC elbow_right	51	2.37	3.65	84	2.27	3.43	101	1.48	2.02	28	2.46	5.58	37	2.41	3.54	23	1.35	3.66	269	2.75	3.93
SumDBC wrist_right	52	1.33	2.51	81	0.77	1.30	98	0.88	2.19	28	0.71	1.98	37	1.27	2.59	21	0.86	1.85	263	0.86	1.98
SumDBC hip right	51	4.06	3.45	85	4.13	3.15	102	3.37	2.98	28	2.50	2.67	37	4.16	4.00	23	2.61	3.03	275	3.92	3.62
SumDBC knee right	52	3.00	3.64	85	3.13	4.03	102	2.85	5.39	28	1.75	3.00	37	1.70	2.53	23	1.65	2.35	275	4.49	5.55
SumDBC ankle_rigth	52	0.81	1.12	85	0.80	1.17	101	0.53	0.93	28	0.29	0.53	37	0.54	0.93	23	0.43	0.84	272	0.49	0.84

* Standard Deviation

	Government administration/Services			Commerce/Transport			Skilled workers/Artisans			Farmers/Servants			Unskilled workers			Army/Navy			Housewives		
	N	Mean	S.D.*	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
SumMSM shoulder_left	52	4.92	4.44	85	4.49	4.70	102	4.22	4.50	28	1.46	2.13	37	4.19	3.47	22	3.27	3.67	276	4.65	4.74
SumMSM elbow left	51	1.94	2.15	84	1.79	2.07	102	1.99	2.30	28	1.04	1.73	37	1.86	1.86	22	1.05	1.46	275	1.89	2.19
SumMSM hip left	52	4.63	3.94	85	3.76	3.40	102	3.64	3.15	28	2.68	2.88	37	3.38	3.56	23	3.09	3.95	276	4.92	3.65
SumMSM knee left	52	3.60	2.48	85	3.27	2.49	102	2.72	2.45	28	1.64	1.66	37	2.62	1.82	23	2.48	2.43	276	2.69	2.24
SumMSM ankle left	51	2.12	2.13	84	2.21	2.21	100	1.65	1.96	28	1.86	1.78	37	1.95	1.67	23	1.17	1.85	276	2.34	2.14
SumMSM shoulder_right	52	4.27	3.94	85	4.55	4.44	102	4.59	3.99	28	2.07	2.39	37	4.89	4.10	23	4.48	2.68	276	4.63	4.44
SumMSM elbow right	51	2.22	2.50	84	2.15	2.45	102	2.25	2.66	28	1.50	1.80	37	2.24	2.44	23	1.52	2.17	273	2.52	2.73
SumMSM hip righ	52	4.19	2.88	85	3.87	2.93	102	3.68	2.73	28	2.96	2.35	37	3.46	2.60	23	3.83	3.04	276	4.53	2.98
SumMSM knee right	52	3.42	2.61	85	3.42	2.60	102	2.66	2.46	28	1.50	1.73	37	2.32	1.47	23	2.17	2.59	276	2.75	2.28
SumMSM ankle right	51	2.12	2.07	84	2.11	2.06	101	1.79	1.85	28	2.29	1.54	37	1.86	1.73	23	1.26	1.57	274	2.42	2.16

* Standard Deviation

1.4.2 SumDBC and SumMSM variables per limbs

1.1.2.1 Descriptive statistics

In general females exhibited higher mean values than men, for both SumDBC and SumMSM limb variables, this as particularly true for the SumMSM_Lower right and left limbs (Table 29).

Table 29 – Descriptive statistics of SumDBC and SumMSM upper and lower limbs, according to sex sub-samples.

	Female			Male			Total sample		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
SumDBC_Upper_left	303	8.08	9.38	299	6.28	6.88	602	7.19	8.27
SumDBC_Upper_Right	303	8.11	9.56	299	7.27	7.86	602	7.70	8.76
SumDBC_Lower_Left	303	8.05	7.63	300	6.36	6.23	603	7.21	7.01
SumDBC_Lower_Right	303	8.58	8.19	300	6.99	6.87	603	7.79	7.60
SumMSM_Upper_Left	303	7.26	7.04	300	7.12	6.70	603	7.19	6.87
SumMSM_Upper_Right	303	7.83	7.24	300	7.78	6.72	603	7.80	6.98
SumMSM_Lower_Left	303	10.53	7.37	300	9.41	7.17	603	9.98	7.29
SumMSM_Lower_Right	303	10.15	6.73	300	9.40	6.36	603	9.77	6.55

1.1.2.2 Hierarchical regression test results

Hierarchical regression was performed in the sum variables where significant differences were found between male and female individuals after using Mann-Whitney test. The regression results clarified that when sex and age were both considered as predictors of the degenerative changes in the lower left limb, only age had a significant contribution (Table 30). Similar observations applied even in the cases were a marginal significant difference between sexes was achieved as observed in the SumDBC in the lower right limb (Table 31).

Table 30- Regression model summary and table of regression coefficients of SumDBC lower left limb.

Model	R	R Square	Adjusted R Square
1) Sex	0,121	0,015	0,013
2) Sex and Age	0,668	0,446	0,444

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	8,053	0,400		20,118	<0.001	7,267	8,839
	sex	-1,689	0,567	-0,121	-2,977	0,003	-2,804	-0,575
2	(Constant)	-5,779	0,707		-8,175	<0.001	-7,168	-4,391
	sex	-0,163	0,432	-0,012	-0,377	0,707	-1,010	0,685
	age	0,247	0,011	0,666	21,614	<0.001	0,225	0,270

Table 31 - Regression model summary and table of regression coefficients of SumDBC lower right limb

Model	R	R Square	Adjusted R Square
1) Sex	0.105	0.011	0.009
2) Sex and Age	0.653	0.427	0.425

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	8.5[illegible]4	[illegible]		[illegible]	[illegible]	[illegible]	9.43[illegible]
	sex	-1.594	0.616	-0.105	-2.587	0.010	[illegible]	-0.384
2	(Constant)	-6.132	0.779		[illegible]	<0.001	-7.662	-4.601
	sex	0.030	0.476	0.002	0.064	0.949	-0.904	0.965
	age	0.263	0.013	0.654	20.860	<0.001	0.238	0.288

1.1.2.3 Kruskal-Wallis test results

Statistically significant difference between occupational groups and the mean values of SumDBC and SumMSM were only absent in the SumMSM right upper limb (p=0.105). Marginally significant values were observed for the SumDBC on the right upper limb (p=0.053), and on the SumMSM right lower limb (p=0.056) (Table 32). To consider theses latter values significant is much to the discretion of the researcher. Based on the historical of results achieved, right side limbs have consistently higher mean values, it is therefore reasonable to asses this "marginal" values as significant. Descriptive statistics can be consulted in table 33.

Table 32 - Kruskal-Wallis test results: SumDBC and SumMSM upper and lower limbs mean difference per occupational groups.

SumDBC	Upper limb		Lower limb		SumMSM	Upper limb		Lower limb	
	Left	Right	Left	Right		Left	Right	Left	Right
H	17.408	12.437	24.003	22.026		18.240	10.506	17.016	12.318
df	6	6	6	6		6	6	6	6
Monte Carlo Sig. (2-tailed)	0.009	0.053	0.001	<0.001		0.006	0.105	0.008	0.056

Table 33 – Descriptive statistics of SumDBC and Sum_MSM upper and lower limbs per occupational groups.

	SumDBC_Upper_Left			SumDBC_Upper_Right			SumDBC_Lower_Left			SumDBC_Lower_Right		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Government administration/Services	53	6.943	7.655	53	8.000	8.467	53	7.170	5.807	53	7.717	6.350
Commerce/Transport	83	6.952	6.764	83	8.133	7.807	84	7.476	6.578	84	8.107	6.890
Skilled workers/Artisans	101	5.782	6.123	101	6.297	6.992	101	6.069	6.992	101	6.812	7.862
Farmers/Servants	29	5.724	7.549	29	6.276	10.395	29	4.379	5.678	29	4.414	4.989
Unskilled workers	37	7.108	7.870	37	9.378	9.968	37	5.946	5.033	37	6.405	5.790
Army/Navy	23	3.522	7.959	23	4.522	7.733	23	4.130	4.732	23	4.696	5.772
Housewives	276	8.293	9.430	276	8.207	9.320	276	8.283	7.652	276	8.866	8.284

	SumMSM_Upper_Left			SumMSM_Upper_Right			SumMSM_Lower_Left			SumMSM_Lower_Right		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Government administration/Services	53	7.962	6.590	53	7.642	6.642	53	11.094	8.162	53	10.509	6.869
Commerce/Transport	84	7.405	7.076	84	7.893	7.061	84	10.333	7.479	84	10.381	6.954
Skilled workers/Artisans	101	7.426	7.125	101	8.059	7.025	101	8.970	6.704	101	8.990	6.193
Farmers/Servants	29	3.069	4.140	29	4.034	4.136	29	6.310	4.622	29	6.931	4.200
Unskilled workers	37	7.162	5.403	37	8.459	6.483	37	8.568	6.185	37	8.162	4.758
Army/Navy	23	5.130	5.864	23	6.913	5.116	23	7.565	7.763	23	8.130	6.737
Housewives	276	7.496	7.124	276	8.098	7.368	276	10.797	7.409	276	10.384	6.778

1.4.3 SumDBC_Total and SumMSM_Total variables

1.1.3.1 Descriptive statistics

Table 34 – Descriptive statistics of SumDBC_Total and SumMSM_Total variables, according to sex sub-samples.

	Female			Male			Total sample		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
SumDBC_Total_Left	303	16.14	15.52	300	12.63	11.83	603	14.39	13.91
SumDBC_Total_Right	303	16.70	15.85	300	14.24	13.33	603	15.47	14.69
SumMSM_Total_Left	303	17.80	13.50	300	16.53	12.80	603	17.17	13.16
SumMSM_Total_Right	303	17.98	12.91	300	17.17	11.90	603	17.58	12.41

1.1.3.2 Hierarchical regression test results

Hierarchical regression was performed in the sum variables where significant differences were found between male and female individuals after using Mann-Whitney test. When sex and age were considered in the outcome of the variable, only age was a significant predictor (Table 35).

Table 35 - Regression model summary and table of regression coefficients of SumDBC_Total left.

Model	R	R Square	Adjusted R Square
1) Sex	0,126	0,016	0,014
2) Sex and Age	0,723	0,522	0,520

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	16,135	0,793		20,343	<0.001	14,578	17,693
	sex	-3,509	1,125	-0,126	-3,120	0,002	-5,717	-1,300
2	(Constant)	-13,575	1,302		-10,427	<0.001	-16,132	-11,018
	sex	-0,229	0,795	-0,008	-0,288	0,774	-1,790	1,333
	age	0,531	0,021	0,721	25,208	<0.001	0,490	0,572

1.1.3.3 Kruskal-Wallis test results

Statistical significant difference between occupational groups and the mean values of SumDBC_Total and SumMSM_Total were found for left and right SumDBC_Total variables, and SumMSM_Total left variable ($p<0.05$). Statistical significance was not achieved in the SumMSM_Total right variable ($p=0.110$) (table 36). Descriptive statistics can be consulted in table 37.

Table 36 - Kruskal-Wallis test results: SumDBC_Total and SumMSM_Total mean difference per occupational groups.

	SumDBC_Total		SumMSM_Total	
	Left	Right	Left	Right
H	20.700	18.63	16.660	10.309
df	6	6	6	6
Monte Carlo Sig. (2-tailed)	0.001	0.005	0.010	0.110

Table 37 – Descriptive statistics of SumDBC_Total and SumMSM_Total per occupational groups.

	SumDBC_Total_Left			SumDBC_Total_Right			SumMSM_Total_Left			SumMSM_Total_Right		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Government administration/	53	14.113	12.352	53	15.717	13.354	53	19.057	13.879	53	18.151	12.314
Commerce/Transport	84	14.345	11.963	84	16.143	13.601	84	17.738	13.275	84	18.274	12.687
Skilled workers/Artisans	101	11.851	12.028	101	13.109	13.563	101	16.396	12.926	101	17.050	12.029
Farmers/Servants	29	10.103	11.706	29	10.690	14.033	29	9.379	7.917	29	10.966	7.665
Unskilled workers	37	13.054	11.974	37	15.784	13.663	37	15.730	10.867	37	16.622	10.460
Army/Navy	23	7.652	11.068	23	9.217	12.792	23	12.696	11.880	23	15.043	10.835
Housewives	276	16.576	15.589	276	17.072	15.737	276	18.293	13.602	276	18.482	13.083

1.4.4 SumDBC_MSM grouped variables

1.1.4.1 Descriptive statistics

The following Table represent the descriptive statistics of the SumDBC_MSM grouped variables. The results are presented for the total sample, and sex sub-samples, according to joint, limbs and total sum.

Table 38 – Descriptive statistics of the SumDBC_MSM grouped variables.

	Female			Male			Total sample		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
SumDBC_MSM_shoulder_left	303	9.16	9.21	299	8.03	7.73	602	8.60	8.52
SumDBC_MSM_shoulder_right	303	9.03	8.77	300	8.92	7.98	603	8.98	8.38
SumDBC_MSM_elbow_left	302	4.49	5.70	297	3.50	4.05	599	4.00	4.97
SumDBC_MSM_elbow_right	301	5.15	6.02	298	4.07	4.82	599	4.61	5.48
SumDBC_MSM_hip_left	303	8.22	5.82	300	7.20	5.84	603	7.71	5.85
SumDBC_MSM_hip_right	303	8.20	5.48	300	7.51	5.31	603	7.86	5.41
SumDBC_MSM_knee_left	303	6.67	6.44	300	5.35	5.06	603	6.02	5.83
SumDBC_MSM_knee_right	303	6.98	6.77	300	5.53	5.50	603	6.26	6.21
SumDBC_MSM_ankle_left	303	2.88	2.61	300	2.34	2.39	603	2.61	2.51
SumDBC_MSM_ankle_right	303	2.86	2.55	300	2.53	2.40	603	2.70	2.48
SumDBC_MSM_total_upper_left	303	15.34	14.97	300	13.38	12.42	603	14.37	13.78
SumDBC_MSM_total_upper_right	303	15.94	15.37	300	15.03	13.45	603	15.49	14.44
SumDBC_MSM_total_lower_left	303	18.59	13.52	300	15.78	12.09	603	17.19	12.89
SumDBC_MSM_total_lower_right	303	18.73	13.15	300	16.39	11.85	603	17.56	12.56
Total_Sum_left	303	33.93	26.90	300	29.16	23.03	603	31.56	25.14
Total_Sum_right	303	34.67	26.61	300	31.41	23.63	603	33.05	25.20

1.1.4.2 Hierarchical regression test results

Hierarchical regression was performed in the sum variables where significant differences were found between male and female individuals after using Mann-Whitney test, or when statistical significance was found to be marginal. As already observed when the variables were explored separately, when sex and age were used to predict the outcome of the values, age was a statistically significant predictor whilst age was not (tables 39 to 46). These results exacerbate the need to control for age in any research dealing with skeletal lesions that are described as degenerative, independently of the cause of degeneration such as ageing process of mechanical strains.

Table 39 - Regression model summary and table of regression coefficients of SumDBC_MSM_Left_Hip.

Model	R	R Square	Adjusted R Square
1) Sex	0,087	0,008	0,006
2) Sex and Age	0,756	0,571	0,569

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	8,221	0,335		24,550	<0.001	7,563	8,879
	sex	-1,021	0,475	-0,087	-2,151	0,032	-1,954	-0,089
2	(Constant)	-4,955	0,519		-9,554	<0.001	-5,974	-3,937
	sex	0,433	0,317	0,037	1,369	0,172	-0,189	1,055
	age	0,235	0,008	0,761	28,064	<0.001	0,219	0,252

Table 40 - Regression model summary and table of regression coefficients of SumDBC_MSM_Left_Knee.

Model	R	R Square	Adjusted R Square
1) Sex	0,113	0,013	0,011
2) Sex and Age	0,619	0,383	0,381

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	6,673	0,333		20,052	<0.001	6,020	7,327
	sex	-1,320	0,472	-0,113	-2,797	0,005	-2,247	-0,393
2	(Constant)	-3,964	0,620		-6,395	<0.001	-5,182	-2,747
	sex	-0,146	0,379	-0,013	-0,385	0,701	-0,889	0,598
	age	0,190	0,010	0,616	18,955	<0.001	0,170	0,210

Table 41 - Regression model summary and table of regression coefficients of SumDBC_MSM_Left_Ankle.

Model	R	R Square	Adjusted R Square
1) Sex	0,108	0,012	0,010
2) Sex and Age	0,465	0,216	0,214

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2,878	0,144		20,045	<0.001	2,596	3,160
	sex	-0,541	0,204	-0,108	-2,659	0,008	-0,941	-0,141
2	(Constant)	-0,534	0,301		-1,773	0,077	-1,125	0,058
	sex	-0,165	0,184	-0,033	-0,895	0,371	-0,526	0,197
	age	0,061	0,005	0,459	12,516	<0.001	0,051	0,071

Table 42 - Regression model summary and table of regression coefficients of SumDBC_MSM_Right_Elbow.

Model	R	R Square	Adjusted R Square
1) Sex	0,099	0,010	0,008
2) Sex and Age	0,627	0,393	0,391

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	5,150	0,315		16,369	<0.001	4,532	5,767
	sex	-1,082	0,446	-0,099	-2,427	0,016	-1,958	0,206
2	(Constant)	-5,068	0,581		-8,720	<0.001	-6,210	-3,927
	sex	0,032	0,354	0,003	0,091	0,928	-0,663	0,728
	age	0,183	0,009	0,628	19,411	<0.001	0,164	0,201

Table 43 - Regression model summary and table of regression coefficients of SumDBC_MSM_Right_Knee.

Model	R	R Square	Adjusted R Square
1) Sex	0,117	0,014	0,012
2) Sex and Age	0,598	0,358	0,356

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	6,983	[illegible]		[illegible]	[illegible]	6,288	[illegible]
	sex	-1,457	0,502	-0,11[illegible]	-2,900	[illegible]	-2,444	[illegible]
2	(Constant)	-3,951	0,673		-5,867	<0.001	-5,274	-2,629
	sex	-0,250	0,411	-0,020	-0,607	0,544	-1,057	0,558
	age	0,195	0,011	0,595	17,937	<0.001	0,174	0,217

Table 44 - Regression model summary and table of regression coefficients of SumDBC_MSM_Lower_Left.

Model	R	R Square	Adjusted R Square
1) Sex	0,109	0,012	0,010
2) Sex and Age	0,748	0,560	0,558

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	18,587	0,737		25,222	<0.001	17,140	[illegible]
	sex	-2,811	1,045	-0,109	-2,690	0,007	-4,863	-0,759
2	(Constant)	-10,071	1,159		-8,690	<0.001	-12,347	-7,795
	sex	0,353	0,708	0,014	0,499	0,618	-1,037	1,742
	age	0,512	0,019	0,750	27,319	<0.001	0,475	0,549

Table 45 - Regression model summary and table of regression coefficients of SumDBC_MSM_Lower_Right.

Model	R	R Square	Adjusted R Square
1) Sex	0,093	0,009	0,007
2) Sex and Age	0,728	0,530	0,529

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	18,729	0,719		26,041	<0.001	17,317	20,142
	sex	-2,343	1,020	-0,093	-2,297	0,022	-4,345	-0,340
2	(Constant)	-8,518	1,166		-7,304	<0.001	-10,808	-6,227
	sex	0,665	0,712	0,026	0,934	0,351	-0,733	2,064
	age	0,487	0,019	0,732	25,810	<0.001	0,450	0,524

Table 46 - Regression model summary and table of regression coefficients of Total_Sum left.

Model	R	R Square	Adjusted R Square
1) Sex	0,095	0,009	0,007
2) Sex and Age	0,778	0,605	0,604

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	33,931	1,439		23,579	0,000	31,105	36,757
	sex	-4,774	2,040	-0,095	-2,340	0,020	-8,781	-0,767
2	(Constant)	-24,364	2,139		-11,388	0,000	-28,566	-20,162
	sex	1,661	1,306	0,033	1,271	0,204	-0,905	4,227
	age	1,042	0,035	0,783	30,099	0,000	0,974	1,110

1.1.4.3 Kruskal-Wallis test results

Statistically significant differences between occupational groups and the mean values of SumDBC_MSM aggregated variables were mostly left sided, with the exception of the elbow (p=0.050), although the value was of marginal significance. On the right side only hip (p=0.036) and knee (p<0.001) exhibited significant differences between occupational groups (Table 47). Descriptive statistics can be consulted in table 49.

Table 47 – Kruskal-Wallis test results: SumDBC_MSM mean differences per occupational groups.

SumDBC_MSM	Left					Right				
	Shoulder	Elbow	Hip	Knee	Ankle	Shoulder	Elbow	Hip	Knee	Ankle
H	13,363	12,450	21,001	22,724	18,597	8,176	10,854	13,356	25,322	8,186
df	6	6	6	6	6	6	6	6	6	6
Monte Carlo Sig. (2-tailed)	0,038	0,050	0,001	<0.001	0,005	0,229	0,091	0,036	<0.001	0,227

Statistically significant differences between occupational groups and the mean values of SumDBC_MSM were found on the left upper limb (p=0.029), and both left (p=0.001) and right (p=0.004) lower limbs. When the variables Total_Sum were analysed, significant differences between occupational groups were only found on the left side (p=0.005). Although, considering the marginal value of significance observed on the right side (p=0.050), one could conceive that the values of Total_Sum between occupation groups were significantly different, though marginal (Table 48). Descriptive statistics can be consulted in table 49.

Table 48 – Kruskal-Wallis test results: SumDBC_MSM_Upper and lower limbs and Total_Sum mean differences per occupational groups.

SumDBC_MSM	Upper limb		Lower limb		Total_Sum	Left	Right
	Left	Right	Left	Right			
H	13.956	7.350	21.787	18.433	H	18.065	12.562
df	6	6	6	6	df	6	6
Monte Carlo Sig. (2-tailed)	0.029	0.289	0.001	0.004	Monte Carlo Sig. (2-tailed)	0.005	0.050

Table 49 - Descriptive statistics of SumDBC_MSM per joint, limbs and total sums according to occupational groups.

	Government administration/Services			Commerce/Transport			Skilled workers/Artisans			Farmers/Servants			Unskilled workers			Army/Navy			Housewives		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
SumDJD_MSM_shoulder_left	52	8.981	8.067	85	8.765	8.399	102	7.794	7.739	28	5.143	5.880	37	8.162	6.866	22	4.636	5.010	276	9.504	9.376
SumDJD_MSM_elbow_left	51	3.980	3.957	84	3.655	4.034	102	3.363	3.843	28	2.857	4.751	37	3.973	4.246	22	2.455	4.788	275	4.589	5.788
SumDJD_MSM_hip_left	52	8.135	6.368	85	7.859	5.780	102	6.824	5.686	28	4.750	4.274	37	7.081	5.751	23	5.522	6.074	276	8.486	5.820
SumDJD_MSM_knee_left	52	6.769	4.655	85	6.000	5.479	102	5.196	5.615	28	3.357	4.011	37	4.568	3.708	23	3.826	4.355	276	6.830	6.497
SumDJD_MSM_ankle_left	52	2.635	2.343	85	2.800	2.716	102	1.980	2.346	28	2.536	2.396	37	2.243	1.817	23	1.522	2.233	276	2.924	2.597
SumDJD_MSM_shoulder_right	52	8.769	7.913	85	9.518	8.712	102	8.520	7.609	28	5.393	6.425	37	10.595	9.124	23	6.870	4.526	276	9.337	8.876
SumDJD_MSM_elbow_right	51	4.588	4.817	84	4.429	5.324	102	3.716	4.327	28	3.964	6.680	37	4.649	5.509	23	2.870	4.732	274	5.212	5.900
SumDJD_MSM_hip_right	52	8.173	5.618	85	8.000	5.405	102	7.049	5.021	28	5.464	4.132	37	7.622	5.433	23	6.435	5.703	276	8.442	5.516
SumDJD_MSM_knee_right	52	6.423	4.980	85	6.553	5.758	102	5.510	6.465	28	3.250	3.460	37	4.027	2.920	23	3.826	4.292	276	7.221	6.872
SumDJD_MSM_ankle_right	52	2.885	2.861	85	2.882	2.683	102	2.304	2.268	28	2.571	1.709	37	2.405	1.992	23	1.696	1.893	276	2.884	2.563

	Government administration/Services			Commerce/Transport			Skilled workers/Artisans			Farmers/Servants			Unskilled workers			Army/Navy			Housewives		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
SumDJD_MSM_total_upper left	52	15.192	12.719	85	14.106	12.886	102	13.127	12.382	28	8.929	10.767	37	14.270	12.514	23	8.652	11.348	276	15.790	15.106
SumDJD_MSM total upper right	52	15.923	13.720	85	15.753	13.930	102	14.235	13.037	28	10.607	13.365	37	17.838	15.527	23	11.435	10.522	276	16.304	15.372
SumDJD_MSM_total lower left	52	18.538	12.719	85	17.647	12.692	102	14.922	12.373	28	10.964	8.775	37	14.514	10.010	23	11.696	11.522	276	19.080	13.561
SumDJD_MSM_total lower right	52	18.385	12.167	85	18.388	12.716	102	15.696	12.348	28	11.571	8.089	37	14.568	8.617	23	12.826	11.452	276	19.250	13.223
Total_Sum_left	52	33.731	24.230	85	31.753	23.749	102	28.049	23.653	28	19.893	18.105	37	28.784	21.636	23	20.348	19.441	276	34.870	27.047
Total_Sum_right	52	34.308	23.840	85	34.141	24.883	102	29.931	24.082	28	22.179	20.020	37	32.405	22.558	23	24.261	20.530	276	35.554	26.727

1.4.5 Test results of SumDBC and SumMSM within occupational groups

Table 50 – Results of the analysis of the "intensity" of lesion, per variables, within occupational groups.

Variables	Government administration/Services			Commerce/Transport			Skilled workers/Artisans			Farmers/Servants			Unskilled workers			Army/Navy			Housewives		
	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p
SumMSM per joint	51	99,02	<0.001	82	139,56	<0.001	99	162,52	<0.001	29	41,85	<0.001	37	68,99	<0.001	21	55,64	<0.001	271	546,26	<0.001
SumDBC per joint	48	179,04	<0.001	76	348,31	<0.001	93	370,28	<0.001	29	87,72	<0.001	36	162,05	<0.001	20	46,88	<0.001	236	1057,03	<0.001
	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p
SumDBC per limb	53	2,79	0,429	83	11,97	0,008	101	8,05	0,041	29	0,876	0,842	37	1,88	0,602	23	7,52	0,056	276	14,93	0,002
SumMSM per limb	53	36,69	<0.001	84	31,49	<0.001	101	26,33	<0.001	29	41,44	<0.001	37	6,21	0,104	23	11,61	0,008	276	180,15	<0.001
											χ^2 (df=9)										
	n	Z-score	p	n	Z-score	p	n	Z-score	p	n	Z-score	p	n	Z-score	p	n	Z-score	p	n	Z-score	p
SumDBC per individual	53	-1,62	0,054	84	-2,56	0,006	101	-1,56	0,056	29	-0,375	0,364	37	-2,15	0,015	23	-1,7	0,044	276	-0,85	0,199
SumMSM per individual	53	-1,3	0,095	84	-1,04	0,151	101	-2,07	0,019	29	-2,61	0,003	37	-1,62	0,058	23	-2,92	0,001	276	-0,74	0,234
	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p	n	χ^2 (df=9)	p
SumDBC_MSM per joint	52	161,93	<0.001	83	245,13	<0.001	101	293,46	<0.001	29	43,91	<0.001	37	122,21	<0.001	21	62,09	<0.001	273	810,78	<0.001
	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p	n	χ^2 (df=3)	p
SumDBC_MSM per limb	53	17,45	0,001	84	30,547	<0.001	101	31,56	<0.001	29	17,65	<0.001	37	3,88	0,281	23	17,99	<0.001	276	110,83	<0.001
	n	Z-score	p	n	Z-score	p	n	Z-score	p	n	Z-score	p	n	Z-score	p	n	Z-score	p	n	Z-score	p
SumDBC_MSM per individual	53	-0,401	0,345	84	-2,62	0,005	101	-2,78	0,003	29	-2,03	0,021	37	-2,62	0,004	23	-3,06	0,001	276	-1,03	0,157

Table 51 - Descriptive statistics of the values of "intensity" of SumDBC, per joint, within occupational groups.

	Government administration and Services					Commerce and transport					Skilled workers and Artisans					Farmers and Servants				
	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.
SumDBC_shoulder_right	52	4,50	0	21	4,85	82	5,15	0	22	5,09	101	3,97	0	16	4,42	29	3,55	0	15	4,19
SumDBC_hip_right	52	4,06	0	17	3,42	83	4,37	0	15	4,34	101	3,61	0	16	4,10	29	3,21	0	23	5,02
SumDBC_shoulder_left	52	4,06	0	15	4,40	83	4,14	0	14	3,51	101	3,41	0	12	2,98	29	2,41	0	9	2,67
SumDBC_hip_left	53	3,51	0	10	2,91	84	4,13	0	12	3,17	101	3,22	0	14	3,15	29	2,38	0	27	5,50
SumDBC_knee_left	53	3,11	0	14	3,31	84	3,17	0	22	4,04	101	2,88	0	27	5,41	29	2,00	0	8	2,15
SumDBC_knee_right	53	2,94	0	17	3,62	84	2,76	0	17	3,78	101	2,49	0	24	4,23	29	1,76	0	17	3,79
SumDBC_elbow_right	52	2,33	0	16	3,63	83	2,30	0	20	3,44	100	1,49	0	10	2,02	29	1,72	0	13	3,23
SumDBC_elbow_left	51	2,04	0	13	3,02	82	1,91	0	17	2,89	101	1,39	0	11	1,96	29	1,69	0	12	2,97
SumDBC_wrist_right	53	1,30	0	10	2,49	84	0,81	0	6	1,18	97	0,89	0	17	2,20	29	0,69	0	10	1,95
SumDBC_wrist_left	52	1,02	0	8	2,05	80	0,78	0	6	1,30	99	0,80	0	7	1,53	29	0,66	0	7	1,40
SumDBC_ankle_right	53	0,79	0	4	1,12	82	0,70	0	7	1,34	100	0,53	0	6	0,94	29	0,41	0	7	1,38
SumDBC_ankle_left	53	0,55	0	3	0,75	84	0,62	0	4	0,92	100	0,37	0	6	0,92	29	0,31	0	2	0,54

	Unskilled workers					Army / Navy					Housewives				
	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.
SumDBC_shoulder_right	37	5,70	0	20	6,08	23	2,61	0	12	3,03	275	4,87	0	33	5,60
SumDBC_hip_right	37	4,16	0	21	4,00	23	2,43	0	12	3,04	273	4,76	0	31	5,40
SumDBC_shoulder_left	37	3,97	0	12	4,04	23	2,39	0	10	3,07	275	4,49	0	26	5,55
SumDBC_hip_left	37	3,70	0	14	2,91	23	1,65	0	8	2,35	275	4,16	0	28	5,22
SumDBC_elbow_right	37	2,41	0	14	3,54	22	1,41	0	18	4,09	275	3,92	0	22	3,62
SumDBC_elbow_left	37	2,11	0	14	3,08	22	1,36	0	11	2,63	273	3,60	0	19	2,94
SumDBC_knee_left	37	1,95	0	10	2,66	23	1,35	0	8	2,12	269	2,75	0	20	3,93
SumDBC_knee_right	37	1,70	0	10	2,53	23	1,35	0	17	3,66	270	2,75	0	26	4,53
SumDBC_wrist_right	37	1,27	0	12	2,59	21	0,95	0	7	1,99	263	0,86	0	18	1,98
SumDBC_wrist_left	36	1,06	0	11	2,34	21	0,86	0	8	1,85	264	0,78	0	21	2,00
SumDBC_ankle_right	37	0,54	0	3	0,93	23	0,43	0	3	0,84	276	0,58	0	5	0,92
SumDBC_ankle_left	37	0,30	0	2	0,57	23	0,35	0	2	0,65	272	0,49	0	7	0,84

Min - minimum value of lesion obtained; Max - maximum value of lesion obtained; S.D. - standard deviation

Table 52 - Descriptive statistics of the values of "intensity" of SumMSM, per joint, within occupational groups.

	Government administration and Services					Commerce and transport					Skilled workers and Artisans					Farmers and Servants				
	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.
SumMSM_Shoulder_left	53	4,83	0	16	4,45	84	4,60	0	17	4,45	101	4,63	0	18	3,99	29	3,00	0	9	2,31
SumMSM_hip_left	53	4,55	0	12	3,95	84	4,55	0	20	4,70	101	4,23	0	21	4,53	29	2,62	0	10	2,85
SumMSM_Shoulder_right	53	4,21	0	16	3,93	84	3,89	0	12	2,94	101	3,67	0	11	2,74	29	2,21	0	6	1,57
SumMSM_hip_righ	53	4,15	0	10	2,87	84	3,81	0	12	3,39	101	3,66	0	11	3,16	29	2,00	0	8	2,38
SumMSM_knee_left	53	3,53	0	9	2,51	84	3,42	0	11	2,62	101	2,74	0	12	2,44	29	1,79	0	7	1,78
SumMSM_knee_right	53	3,43	0	11	2,58	84	3,31	0	11	2,48	101	2,68	0	11	2,46	29	1,59	0	5	1,66
SumMSM_elbow_right	52	2,17	0	9	2,49	83	2,24	0	8	2,21	101	2,27	0	12	2,67	29	1,52	0	7	2,11
SumMSM_ankle_left	52	2,08	0	8	2,13	83	2,18	0	12	2,45	101	2,00	0	10	2,31	29	1,48	0	7	1,77
SumMSM_ankle_right	52	2,08	0	7	2,07	83	2,13	0	8	2,06	100	1,81	0	8	1,85	29	1,45	0	5	1,72
SumMSM_elbow_left	52	1,90	0	9	2,14	83	1,81	0	7	2,07	99	1,67	0	6	1,96	29	1,03	0	6	1,70

	Unskilled workers					Army / Navy					Housewives				
	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.
SumMSM_Shoulder_right	37	4,89	0	19	4,10	23	4,48	0	9	2,68	276	4,92	0	12	3,65
SumMSM_Shoulder_left	37	4,19	0	14	3,47	23	3,83	0	9	3,04	276	4,65	0	21	4,74
SumMSM_hip_righ	37	3,46	0	10	2,60	22	3,27	0	13	3,67	276	4,63	0	21	4,44
SumMSM_hip_left	37	3,38	0	12	3,56	23	3,09	0	11	3,95	276	4,53	0	12	2,98
SumMSM_knee_left	37	2,62	0	7	1,82	23	2,48	0	8	2,43	276	2,75	0	11	2,28
SumMSM_knee_right	37	2,32	0	5	1,47	23	2,17	0	9	2,59	276	2,69	0	9	2,24
SumMSM_elbow_right	37	2,24	0	8	2,44	23	1,52	0	8	2,17	273	2,52	0	12	2,73
SumMSM_ankle_left	37	1,95	0	5	1,67	23	1,26	0	5	1,57	274	2,42	0	8	2,16
SumMSM_elbow_left	37	1,86	0	7	1,86	23	1,17	0	7	1,85	276	2,34	0	8	2,14
SumMSM_ankle_right	37	1,86	0	6	1,73	22	1,05	0	5	1,46	275	1,89	0	10	2,19

Min - minimum value of lesion obtained; Max - maximum value of lesion obtained; S.D. - standard deviation

Table 53 - Descriptive statistics of the values of "intensity" of SumDBC, per limb, within occupational groups.

	Government administration and Services					Commerce and transport					Skilled workers and Artisans					Farmers and Servants				
	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.
SumDBC_Upper_Right	53	8,00	0	29	8,47	83	8,13	0	34	7,81	101	6,81	0	40	7,86	29	6,28	0	44	10,40
SumDBC_Lower_Right	53	7,72	0	24	6,35	84	8,11	0	36	6,89	101	6,30	0	37	6,99	29	5,72	0	27	7,55
SumDBC_Lower_Left	53	7,17	0	22	5,81	84	7,48	0	29	6,58	101	6,07	0	40	6,99	29	4,41	0	21	4,99
SumDBC_Upper_left	53	6,94	0	30	7,65	83	6,95	0	25	6,76	101	5,78	0	29	6,12	29	4,38	0	23	5,68

	Unskilled workers					Army / Navy					Housewives				
	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.
SumDBC_Upper_Right	37	9,38	0	32	9,97	23	4,70	0	23	5,77	276	8,87	0	36	8,28
SumDBC_Upper_left	37	7,11	0	27	7,87	23	4,52	0	35	7,73	276	8,29	0	49	9,43
SumDBC_Lower_Right	37	6,41	0	26	5,79	23	4,13	0	14	4,73	276	8,28	0	40	7,65
SumDBC_Lower_Left	37	5,95	0	26	5,03	23	3,52	0	31	7,96	276	8,21	0	69	9,32

Min - minimum value of lesion obtained; Max - maximum value of lesion obtained; S.D. - standard deviation

Table 54 - Descriptive statistics of the values of "intensity" of SumMSM, per limb, within occupational groups.

Government administration and Services	N	Mean	Min	Max	S.D.
SumMSM_Lower_Left	53	11,09	0	30	8,16
SumMSM_Lower_Right	53	10,51	0	27	6,87
SumMSM_Upper_Left	53	7,96	0	25	6,59
SumMSM_Upper_Right	53	7,64	0	28	6,64

Commerce and transport	N	Mean	Min	Max	S.D.
SumMSM_Lower_Left	84	10,38	0	31	6,95
SumMSM_Lower_Right	84	10,33	0	30	7,48
SumMSM_Upper_Left	84	7,89	0	27	7,06
SumMSM_Upper_Right	84	7,40	0	30	7,08

Skilled workers and Artisans	N	Mean	Min	Max	S.D.
SumMSM_Lower_Left	[illegible]	[illegible]	0	31	6,19
SumMSM_Lower_Right	101	8,97	0	27	6,70
SumMSM_Upper_Left	101	8,06	0	31	7,03
SumMSM_Upper_Right	101	7,43	0	30	7,13

Farmers and Servants	N	Mean	Min	Max	S.D.
SumMSM_Lower_Left	29	6,93	0	14	4,20
SumMSM_Lower_Right	29	6,31	0	15	4,62
SumMSM_Upper_Left	29	4,03	0	12	4,14
SumMSM_Upper_Right	29	3,07	0	13	4,14

Unskilled workers	N	Mean	Min	Max	S.D.
SumMSM_Lower_Left	37	8,57	0	21	6,18
SumMSM_Upper_Right	37	8,46	0	27	6,48
SumMSM_Lower_Right	37	8,16	1	19	4,76
SumMSM_Upper_Left	37	7,16	0	22	5,40

Army / Navy	N	Mean	Min	Max	S.D.
SumMSM_Lower_Left	23	8,13	0	22	6,74
SumMSM_Upper_Right	23	7,57	0	24	7,76
SumMSM_Lower_Right	23	6,91	0	21	5,12
SumMSM_Upper_Left	23	5,13	0	22	5,86

Housewives	N	Mean	Min	Max	S.D.
SumMSM_Lower_Left	[illegible]	[illegible]	[illegible]	30	[illegible]
SumMSM_Upper_Right	276	10,38	0	28	6,78
SumMSM_Lower_Right	276	8,10	0	35	7,37
SumMSM_Upper_Left	276	7,50	0	32	7,12

Min - minimum value of lesion obtained; Max - maximum value of lesion obtained; S.D. - standard deviation

Table 55 - Descriptive statistics of the values of "intensity" of SumDBC, per individual, within occupational groups.

Government administration and Services	N	Mean	Min	Max	S.D.
SumDBC_Total_Left	53	14,11	0	48	12,35
SumDBC_Total_Right	53	15,72	0	50	13,35

Commerce and transport	N	Mean	Min	Max	S.D.
SumDBC_Total_Left	84	14,35	0	47	11,96
SumDBC_Total_Right	84	16,14	0	70	13.60

Skilled workers and Artisans	N	Mean	Min	Max	S.D.
SumDBC_Total_Left	101	11,85	0	[illegible]	[illegible]
SumDBC_Total_Right	101	13,11	0	59	13,56

Farmers and Servants	N	Mean	Min	Max	S.D.
SumDBC_Total_Left	29	10,10	0	44	11,71
SumDBC_Total_Right	29	10,69	0	52	14,03

Unskilled workers	N	Mean	Min	Max	S.D.
SumDBC_Total_Left	37	13,05	0	52	11,97
SumDBC_Total_Right	37	15,78	0	47	13,66

Army / Navy	N	Mean	Min	Max	S.D.
SumDBC_Total_Left	23	7,65	0	45	11,07
SumDBC_Total_Right	23	9,22	0	58	12,79

Housewives	N	Mean	Min	Max	S.D.
SumDBC_Total_Left	276	16,88	0	81	15,89
SumDBC_Total_Right	276	17,07	0	91	15,74

Min - minimum value of lesion obtained; Max - maximum value of lesion obtained; S.D. - standard deviation

Table 56 - Descriptive statistics of the values of "intensity" of SumMSM, per individual, within occupational groups.

Government administration and Services	N	Mean	Min	Max	S.D.
SumMSM_Total_Left	53	19,06	0	55	13,88
SumMSM_Total_Right	53	18,15	0	55	12,31

Commerce and transport	N	Mean	Min	Max	S.D.
SumMSM_Total_Left	84	17,74	0	57	15,27
SumMSM_Total_Right	84	18,27	0	51	12,69

Skilled workers and Artisans	N	Mean	Min	Max	S.D.
SumMSM_Total_Left	101	16,40	0	55	12,95
SumMSM_Total_Right	101	17,05	0	50	12,03

Farmers and Servants	N	Mean	Min	Max	S.D.
SumMSM_Total_Left	29	9,38	0	28	7,92
SumMSM_Total_Right	29	10,97	0	26	7,66

Unskilled workers	N	Mean	Min	Max	S.D.
SumMSM_Total_Left	37	15,73	2	39	10,87
SumMSM_Total_Right	37	16,62	2	42	10,46

Army / Navy	N	Mean	Min	Max	S.D.
SumMSM_Total_Left	23	12,70	0	36	11,88
SumMSM_Total_Right	23	15,04	2	41	10,84

Housewives	N	Mean	Min	Max	S.D.
SumMSM_Total_Left	276	18,29	0	58	13.60
SumMSM_Total_Right	276	18,48	0	63	13,08

Min - minimum value of lesion obtained; Max - maximum value of lesion obtained; S.D. - standard deviation

Table 57 - Descriptive statistics of the values of "intensity" of SumDBC_MSM, per joint, within occupational groups.

Government administration and Services	N	Mean	Min	Max	S.D.
SumDBC_MSM_shoulder_left	53	8,81	0	31	8,08
SumDBC_MSM_shoulder_right	53	8,62	0	32	7,91
SumDBC_MSM_hip_right	53	8,13	0	25	5,57
SumDBC_MSM_hip_left	53	8,06	0	21	6,33
SumDBC_MSM_knee_left	53	6,64	0	16	4,70
SumDBC_MSM_knee_right	53	6,38	0	20	4,94
SumDBC_MSM_elbow_right	52	4,50	0	17	4,81
SumDBC_MSM_elbow_left	52	3,90	0	17	3,96
SumDBC_MSM_ankle_right	53	2,83	0	10	2,86
SumDBC_MSM_ankle_left	53	2,58	0	8	2,35

Commerce and transport	N	Mean	Min	Max	S.D.
SumDBC_MSM_shoulder_left	84	9,62	0	36	8,71
SumDBC_MSM_shoulder_right	84	8,87	0	34	8,39
SumDBC_MSM_hip_right	84	8,02	0	24	5,43
SumDBC_MSM_hip_left	84	7,90	0	23	5,80
SumDBC_MSM_knee_left	84	6,58	0	31	5,79
SumDBC_MSM_knee_right	84	6,07	0	26	5,47
SumDBC_MSM_elbow_right	83	4,48	0	32	5,33
SumDBC_MSM_elbow_left	83	3,70	0	18	4,04
SumDBC_MSM_ankle_right	84	2,92	0	13	2,68
SumDBC_MSM_ankle_left	84	2,83	0	10	2,71

Skilled workers and Artisans	N	Mean	Min	Max	S.D.
SumDBC_MSM_shoulder_left	101	8,60	0	32	7,60
SumDBC_MSM_shoulder_right	101	7,84	0	36	7,76
SumDBC_MSM_hip_right	101	7,08	0	19	5,04
SumDBC_MSM_hip_left	101	6,88	0	22	5,68
SumDBC_MSM_knee_left	101	5,56	0	32	6,47
SumDBC_MSM_knee_right	101	5,23	0	28	5.63
SumDBC_MSM_elbow_right	101	3,74	0	21	4,34
SumDBC_MSM_elbow_left	101	3,39	0	19	3,85
SumDBC_MSM_ankle_right	101	2,32	0	9	2,28
SumDBC_MSM_ankle_left	101	2,00	0	11	2,35

Farmers and Servants	N	Mean	Min	Max	S.D.
SumDBC_MSM_shoulder_left	29	5,41	0	14	4,07
SumDBC_MSM_shoulder_right	29	5,21	0	28	6,39
SumDBC_MSM_hip_right	29	5,07	0	17	5,79
SumDBC_MSM_hip_left	29	4,62	0	13	4,25
SumDBC_MSM_knee_left	29	3,86	0	31	6,58
SumDBC_MSM_knee_right	29	3,31	0	16	3,95
SumDBC_MSM_elbow_right	29	3,14	0	12	3,45
SumDBC_MSM_elbow_left	29	2,79	0	18	4,68
SumDBC_MSM_ankle_right	29	2.52	0	7	1,70
SumDBC_MSM_ankle_left	29	2,45	0	9	2,40

Unskilled workers	N	Mean	Min	Max	S.D.
SumDBC_MSM_shoulder_right	37	10,59	0	33	9,12
SumDBC_MSM_shoulder_left	37	8,16	1	26	6,87
SumDBC_MSM_hip_right	37	7,62	0	25	5,43
SumDBC_MSM_hip_left	37	7,08	0	24	5,75
SumDBC_MSM_elbow_right	37	4,65	0	21	5,51
SumDBC_MSM_knee_left	37	4,57	0	16	3,71
SumDBC_MSM_knee_right	37	4,03	0	11	2,92
SumDBC_MSM_elbow_left	37	3,97	0	16	4,25
SumDBC_MSM_ankle_right	37	2,41	0	6	1,99
SumDBC_MSM_ankle_left	37	2,24	0	6	1,82

Army / Navy	N	Mean	Min	Max	S.D.
SumDBC_MSM_shoulder_right	23	[illegible]	0	17	[illegible]
SumDBC_MSM_shoulder_left	23	6.43	0	20	5,70
SumDBC_MSM_hip_right	23	5,52	0	18	6,07
SumDBC_MSM_hip_left	22	4,64	0	15	5,01
SumDBC_MSM_elbow_right	23	3,83	0	16	4,36
SumDBC_MSM_knee_left	23	3,83	0	16	4,29
SumDBC_MSM_knee_right	23	2,87	0	20	4,73
SumDBC_MSM_elbow_left	22	2,45	0	21	4,79
SumDBC_MSM_ankle_right	23	1,70	0	6	1,89
SumDBC_MSM_ankle_left	23	1.52	0	9	2,23

Housewives	N	Mean	Min	Max	S.D.
SumDBC_MSM_shoulder_right	276	9.50	0	44	9,38
SumDBC_MSM_shoulder_left	276	9,34	0	42	8,88
SumDBC_MSM_hip_right	276	8,49	0	29	5,82
SumDBC_MSM_hip_left	276	8.44	0	30	5.52
SumDBC_MSM_elbow_right	276	7.22	0	29	6.87
SumDBC_MSM_knee_left	276	6,83	0	37	6.50
SumDBC_MSM_knee_right	274	5,21	0	29	5.90
SumDBC_MSM_elbow_left	275	4,59	0	35	5.79
SumDBC_MSM_ankle_right	276	2.92	0	10	2,60
SumDBC_MSM_ankle_left	276	2,88	0	13	2.56

Min - minimum value of lesion obtained; Max - maximum value of lesion obtained; S.D. - standard deviation

Table 58 - Descriptive statistics of the values of "intensity" of SumDBC_MSM, per limb, within occupational groups.

	Government administration and Services					Commerce and transport					Skilled workers and Artisans					Farmers and Servants				
	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D.
SumDBC_MSM_lower_right	53	17,34	1	45	11,47	84	17,52	0	57	12,10	101	14,96	0	58	11,81	29	[illegible],07	0	28	7,78
SumDBC_MSM_lower_left	53	17,28	0	42	12,17	84	16,81	0	56	12,08	101	14,11	0	54	11,72	29	10.38	0	31	8,51
SumDBC_MSM_upper_right	53	14,34	0	41	13,00	84	14,79	0	52	13,13	101	13,20	0	61	12,23	29	9,76	0	54	12,82
SumDBC_MSM_upper_left	53	13,64	0	42	12,00	84	13,20	0	44	12,10	101	12,01	0	48	11,51	29	[illegible],28	0	39	10,26

	Unskilled workers					Army / Navy					Housewives				
	N	Mean	Min	Max	S.D	N	Mean	Min	Max	S.D	N	Mean	Min	Max	S.D.
SumDBC_MSM_upper_right	37	16,51	0	48	14,81	23	11,96	0	34	10,64	276	18,55	0	54	12,73
SumDBC_MSM_lower_right	37	14,05	1	33	8,17	23	10,87	0	35	10,70	276	18,24	0	64	12,98
SumDBC_MSM_lower_left	37	13,89	1	43	9,44	23	10,52	1	45	9,63	276	15,33	0	85	14,68
SumDBC_MSM_upper_left	37	13,16	1	42	11,83	23	7,65	0	43	10,53	276	14,82	0	68	14,41

Min - minimum value of lesion obtained; Max - maximum value of lesion obtained; S.D. - standard deviation

Table 59 - Descriptive statistics of the values of "intensity" of SumDBC_MSM, per individual (Total_Sum), within occupational groups

	Government administration and Services					Commerce and transport					Skilled workers and Artisans					Farmers and Servants				
	N	Mean	Min	Max	S.D.	N	Mean	Min	Max	S.D	N	Mean	Min	Max	S.D	N	Mean	Min	Max	S.D.
Total_Sum_left	53	33,17	0	88	24,34	84	32,08	0	104	23,69	101	28,25	0	99	23,69	29	19,48	0	60	17,92
Total_Sum_right	53	33,87	1	87	23,83	84	34,42	0	115	24,90	101	30,16	0	104	24,09	29	21,66	0	76	19,86

	Unskilled workers					Army / Navy					Housewives				
	N	Mean	Min	Max	S.D	N	Mean	Min	Max	S.D	N	Mean	Min	Max	S.D
Total_Sum_left	37	28,78	3	89	21,64	23	20,35	0	64	19,44	276	34,67	0	123	27,05
Total_Sum_right	37	32,41	4	73	22,56	23	24,26	3	83	20,53	276	35,55	0	121	26,73

Min - minimum value of lesion obtained; Max - maximum value of lesion obtained; S.D. - standard deviation

1.4.6 Results of the statistical tests performed in the Grouped_Variables, for the sub-sample of 48 individuals with specific occupations

Table 60 - Kruskal Wallis test results of the SumDBC variable for the specific occupations: joints.

Kruskal Wallis Test		Shoulder		Elbow		Wrist		Hip		Knee		Ankle	
	SumDBC	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
	H	2.96	0.66	0.31	0.57	2.97	0.20	1.46	0.83	3.43	1.16	3.03	0.15
	df	3	3	3	3	3	3	3	3	3	3	3	3
Monte Carlo Sig.		0.41	0.89	0.96	0.91	0.41	0.98	0.70	0.84	0.34	0.77	0.39	0.99

H- value of the test, df - degrees of freedom; p - significance value

Table 61 - Kruskal Wallis test results of the SumMSM variable for the specific occupations: joints.

Kruskal Wallis Test		Shoulder		Elbow		Hip		Knee		Ankle	
	SumMSM	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
	H	1.91	0.73	1.71	4.86	5.04	2.61	4.68	6.51	2.52	0.11
	df	3	3	3	3	3	3	3	3	3	3
Monte Carlo Sig.		0.60	0.87	0.65	0.18	0.17	0.46	0.20	0.09	0.47	0.99

H- value of the test; df - degrees of freedom; p - significance value

Table 62 - Kruskal Wallis test results of the SumDBC_MSM variable for the specific occupations: joints.

Kruskal Wallis Test		Shoulder		Elbow		Hip		Knee		Ankle	
	SumDBC_MSM	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
	H	2.16	0.86	2.07	2.25	2.54	0.56	3.08	2.48	2.42	0.01
	df	3	3	3	3	3	3	3	3	3	3
Monte Carlo Sig.		0.55	0.84	0.55	0.53	0.47	0.91	0.39	0.49	0.49	1.00

H- value of the test; df - degrees of freedom; p - significance value

Table 63 - Kruskal Wallis test results of the SumDBC_MSM variable for the specific occupations: limbs and total sum.

Kruskal Wallis Test		Upper limb		Lower limb		Total	Sum
	SumDBC_MSM	Left	Right	Left	Right	Left	Right
	H	1.90	1.25	2.88	1.03	2.79	1.37
	df	3	3	3	3	3	3
Monte Carlo Sig.		0.61	0.75	0.42	0.81	0.43	0.72

H- value of the test; df - degrees of freedom; p - significance value

1.5 Appendix_Indices

Table 64 – Descriptive statistics of the postcranial indices according to occupational groups.

	Government administration/Services			Commerce/Transport			Skilled workers/Artisans			Farmers/Servants			Unskilled workers			Army/Navy			Housewives		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
Humerus_left_RI	47	19.83	1.44	79	20.07	1.21	97	20.22	1.65	27	20.21	1.26	34	20.98	1.40	22	20.06	1.31	260	19.45	1.35
Humerus_right_ RI	46	20.13	1.61	82	20.21	1.37	98	20.27	1.62	27	20.23	1.47	36	21.18	1.26	22	20.09	1.52	257	19.46	1.38
Radius_left_ RI	44	18.44	1.63	78	18.76	1.24	96	18.63	1.76	28	18.54	1.20	34	18.97	1.70	21	18.35	1.25	239	18.10	1.35
Radius_right_ RI	46	18.24	1.39	77	18.52	1.48	91	18.34	1.50	28	18.06	1.27	33	18.51	1.47	23	18.89	1.17	240	18.01	1.34
Ulna_left_ RI	42	14.76	1.33	66	14.92	1.30	90	15.16	1.34	28	15.08	1.11	33	15.67	1.35	19	14.56	1.16	211	14.62	1.11
Ulna_right_ RI	42	14.59	1.34	67	15.12	1.37	90	15.18	1.29	28	15.30	1.10	36	15.86	1.32	18	14.58	0.99	214	14.70	1.08
Femur_left_ RI	51	20.19	1.45	78	20.07	1.14	99	20.22	1.17	29	20.41	1.25	36	20.59	1.15	23	19.87	1.31	262	20.03	1.23
Femur_right_ RI	52	20.20	1.22	82	20.11	1.14	101	20.16	1.19	29	20.32	1.16	37	20.53	1.13	23	19.59	0.99	266	19.99	1.29
Tibia_left_ RI	51	20.59	1.35	83	20.69	1.42	95	20.95	1.47	27	21.22	2.08	35	21.35	1.32	23	19.96	1.12	261	20.45	1.39
Tibia_right_RI	48	20.60	1.29	80	20.84	1.49	94	21.04	1.45	28	21.21	2.15	36	21.40	1.23	23	20.04	1.25	258	20.39	1.43
Femur_left_PI	52	87.99	6.30	82	86.11	8.91	97	87.43	7.32	28	81.39	7.29	37	84.94	6.37	23	88.74	10.35	271	83.60	7.74
Femur_right_PI	53	89.40	7.15	83	87.80	8.81	100	88.78	7.46	29	83.38	8.54	37	86.98	7.30	23	90.45	9.54	273	86.03	7.95
Tibia_left_PI	51	71.86	5.12	84	72.88	6.40	100	73.40	6.32	29	74.56	4.22	36	73.11	5.97	23	73.18	5.03	274	74.71	5.74
Tibia_right_PI	51	73.06	5.17	83	73.20	6.83	101	73.61	6.41	29	75.34	5.04	37	73.67	7.40	23	73.84	5.08	272	75.57	5.95
Humerus_left_DI	51	93.89	8.27	81	92.38	7.34	98	90.46	7.08	28	93.25	7.36	36	89.96	6.78	21	92.06	5.43	270	90.55	7.96
Humerus_right_DI	49	95.83	7.53	83	94.06	8.06	100	93.36	6.70	28	97.00	7.07	36	93.48	7.38	23	95.03	6.16	271	93.79	7.94
Radius_left_DI	52	76.09	6.19	82	77.62	6.42	99	77.14	6.57	29	73.00	6.69	35	76.96	6.57	22	76.18	7.66	267	74.15	6.40
Radius_right_DI	51	75.80	6.39	78	77.36	6.50	99	74.37	6.89	29	69.83	6.17	36	75.69	7.22	22	74.85	8.47	270	72.43	6.22
Ulna_left_DI	50	78.69	7.65	81	77.95	6.04	99	77.01	6.40	29	76.81	6.46	37	78.95	7.05	23	78.09	6.75	264	76.04	6.85
Ulna_right_DI	51	75.62	6.86	80	76.10	5.74	98	75.22	5.95	29	76.09	5.26	37	78.15	6.00	23	78.45	5.74	269	74.67	6.19
Femur_left_DI	52	108.00	10.08	81	105.67	9.84	99	108.28	9.09	29	102.17	8.58	37	105.18	7.32	23	110.07	8.42	273	105.24	8.59
Femur_right_DI	53	109.54	10.21	84	108.06	9.43	100	109.41	8.32	29	104.26	9.15	37	107.39	8.37	23	112.26	9.13	273	107.23	8.51

Table 65 - Values of Spearman's correlation between SumDBC_MSM and indices in the total sample: upper limb.

		humerus_left_RI	radius_left_RI	ulna_left_RI	humerus_left_DI	radius_left_DI	ulna_left_DI
SumDJD_MSM_upper_left	Correlation Coefficient	.139(**)	.091(*)	-0,002	-.092(*)	0,044	-0,012
	Sig. (2-tailed)	**0,001**	**0,035**	0,959	**0,027**	0,287	**0,771**
	N	566	540	489	585	586	583
SumDJD_Upper_left	Correlation Coefficient	.118(**)	0,070	0,011	-.082(*)	0,025	-0,013
	Sig. (2-tailed)	**0,005**	**0,103**	0,805	**0,046**	**0,539**	0,761
	N	566	540	489	585	586	583
SumMSM_Upper_Left	Correlation Coefficient	.171(**)	.111(**)	-0,003	-0,077	0,063	-0,026
	Sig. (2-tailed)	**<0.001**	**0,010**	0,945	0,061	0,126	**0,538**
	N	566	540	489	585	586	583

		humerus_right_RI	radius_right_RI	ulna_right_RI	humerus_right_DI	radius_right_DI	ulna_right_DI
SumDJD_MSM_upper_right	Correlation Coefficient	.165(**)	.095(*)	0,045	-.139(**)	0,052	-0,049
	Sig. (2-tailed)	**<0.001**	**0,027**	0,316	**0,001**	0,207	0,240
	N	568	538	495	590	585	587
SumDJD_Upper_Right	Correlation Coefficient	.165(**)	.099(*)	0,078	-.126(**)	0,042	-0,045
	Sig. (2-tailed)	**<0.001**	**0,021**	0,084	**0,002**	0,313	0,274
	N	568	538	495	590	585	587
SumMSM_Upper_Right	Correlation Coefficient	.158(**)	.085(*)	0,019	-.118(**)	0,062	-0,046
	Sig. (2-tailed)	**<0.001**	**0,049**	0,678	**0,004**	0,136	0,267
	N	568	538	495	590	585	587

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 66 - Values of Spearman's correlation between SumDBC_MSM and indices in the total sample: lower limb.

		femur_left_RI	tibia_left_RI	femur_left_PI	tibia_left_PI	femur_left_DI
SumDJD_MSM_lower_left	Correlation Coefficient	.307(**)	0,080	-.137(**)	-0,079	-.159(**)
	Sig. (2-tailed)	**<0.001**	0,054	**0,001**	0,053	**<0.001**
	N	578	575	590	597	594
SumDJD_Lower_Left	Correlation Coefficient	.279(**)	0,075	-.140(**)	-.088(*)	-.164(**)
	Sig. (2-tailed)	**<0.001**	0,071	**0,001**	**0,031**	**<0.001**
	N	578	575	590	597	594
SumMSM_Lower_Left	Correlation Coefficient	.295(**)	0,071	-.094(*)	-0,058	-.118(**)
	Sig. (2-tailed)	**<0.001**	0,091	**0,022**	0,156	**0,004**
	N	578	575	590	597	594

		femur_right_RI	tibia_right_RI	femur_right_PI	tibia_right_PI	femur_right_DI
SumDJD_MSM_lower_right	Correlation Coefficient	.260(**)	0,054	-.081(*)	-.107(**)	-.138(**)
	Sig. (2-tailed)	**<0.001**	0,199	**0,049**	**0,009**	**0,001**
	N	590	567	598	596	599
SumDJD_Lower_Right	Correlation Coefficient	.232(**)	0,026	-0,077	-.081(*)	-.139(**)
	Sig. (2-tailed)	**<0.001**	0,541	0,061	**0,048**	**0,001**
	N	590	567	598	596	599
SumMSM_Lower_Right	Correlation Coefficient	.263(**)	0,073	-0,059	-.101(*)	-.107(**)
	Sig. (2-tailed)	**<0.001**	0,081	0,151	**0,013**	**0,009**
	N	590	567	598	596	599

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 67 - Values of Spearman's correlation between SumDBC_MSM and indices within occupational groups: upper limb.

		SumDJD_MSM_upper_left						SumDJD_MSM_upper_right					
		RI			DI			RI			DI		
		Humerus	Radius	Ulna	Humerus	Radius	Ulna	Humerus	Radius	Ulna	Humerus	Radius	Ulna
Government administration Services	r_s	0,257	0,261	0,060	0,152	0,002	-0,049	0,214	0,166	0,131	-0,054	0,102	-0,130
	p	0,081	0,087	0,706	0,286	0,990	0,735	0,153	0,271	0,407	0,712	0,474	0,363
	N	47	44	42	51	52	50	46	46	42	49	51	51
Commerce/Transport	r_s	0,166	0,042	-0,078	-0,162	0,192	0,056	0,181	0,030	-0,102	-0,135	0,238	0,140
	p	0,144	0,715	0,533	0,149	0,083	0,618	0,104	0,795	0,410	0,224	**0,036**	0,216
	N	79	78	66	81	82	81	82	77	67	83	78	80
Skilled workers/Artisans	r_s	0,196	0,100	0,127	-0,073	0,109	0,110	0,102	0,189	0,151	0,031	0,102	0,042
	p	0,055	0,331	0,231	0,475	0,284	0,278	0,315	0,072	0,157	0,758	0,313	0,679
	N	97	96	90	98	99	99	98	91	90	100	99	98
Farmers/Servants	r_s	0,121	0,020	0,074	-0,396	0,112	-0,200	0,080	0,021	-0,064	-0,429	-0,049	-0,188
	p	0,547	0,920	0,709	**0,037**	0,563	0,299	0,692	0,914	0,745	**0,023**	0,802	0,330
	N	27	28	28	28	29	29	27	28	28	28	29	29
Unskilled workers	r_s	0,062	-0,053	-0,080	-0,245	0,339	-0,350	0,169	0,016	0,009	-0,132	0,064	-0,212
	p	0,729	0,767	0,658	0,150	**0,046**	**0,033**	0,325	0,928	0,957	0,443	0,709	0,207
	N	34	34	33	36	35	37	36	33	36	36	36	37
Army/Navy	r_s	-0,139	-0,038	-0,182	0,048	0,209	0,184	-0,128	-0,135	-0,337	-0,069	0,072	0,343
	p	0,539	0,870	0,456	0,837	0,351	0,402	0,570	0,538	0,172	0,753	0,751	0,109
	N	22	21	19	21	22	23	22	23	18	23	22	23
Housewives	r_s	0,152	0,107	-0,039	-0,076	-0,056	-0,005	0,206	0,111	0,049	-0,161	-0,034	-0,086
	p	**0,014**	0,097	0,575	0,212	0,362	0,941	**0,001**	0,087	0,476	**0,008**	0,574	0,160
	N	260	239	211	270	267	264	257	240	214	271	270	269

Table 68 - Values of Spearman's correlation between SumDBC_MSM and indices within occupational groups: lower limb.

		SumDJD_MSM_lower_left					SumDJD_MSM_lower_right				
		RI		PI		DI	RI		PI		DI
		Femur	Tibia	Femur	Tibia	Femur	Femur	Tibia	Femur	Tibia	Femur
Government administration Services	r_s	0,415	0,079	-0,412	-0,271	-0,302	0,386	-0,008	-0,370	-0,172	-0,264
	p	**0,002**	0,582	**0,002**	0,054	**0,030**	**0,005**	0,955	**0,006**	0,226	0,056
	N	51	51	52	51	52	52	48	53	51	53
Commerce/Transport	r_s	0,258	-0,069	-0,113	-0,148	-0,069	0,160	-0,074	-0,070	-0,101	0,023
	p	**0,023**	0,534	0,310	0,179	0,541	0,151	0,514	0,528	0,364	0,834
	N	78	83	82	84	81	82	80	83	83	84
Skilled workers/Artisans	r_s	0,259	0,104	-0,236	-0,109	-0,318	0,284	0,041	-0,155	-0,147	-0,320
	p	**0,010**	0,316	**0,020**	0,280	**0,001**	**0,004**	0,691	0,124	0,142	**0,001**
	N	99	95	97	100	99	101	94	100	101	100
Farmers/Servants	r_s	0,452	0,271	-0,270	0,061	-0,060	0,422	0,299	-0,058	0,145	0,080
	p	**0,014**	0,172	0,165	0,755	0,759	**0,022**	0,122	0,765	0,453	0,678
	N	29	27	28	29	29	29	28	29	29	29
Unskilled workers	r_s	0,246	0,196	-0,176	0,106	-0,134	0,249	0,140	0,068	0,048	0,058
	p	0,149	0,260	0,298	0,538	0,428	0,137	0,416	0,691	0,779	0,731
	N	36	35	37	36	37	37	36	37	37	37
Army/Navy	r_s	-0,144	-0,486	0,467	-0,294	-0,205	-0,007	-0,456	0,238	-0,437	-0,171
	p	0,513	**0,019**	**0,025**	0,173	0,349	0,975	**0,029**	0,275	**0,037**	0,436
	N	23	23	23	23	23	23	23	23	23	23
Housewives	r_s	0,390	0,163	-0,074	-0,060	-0,115	0,308	0,140	-0,032	-0,149	-0,123
	p	**<0.001**	**0,008**	0,227	0,323	0,058	**<0.001**	**0,024**	0,604	**0,014**	**0,043**
	N	262	261	271	274	273	266	258	273	272	273